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PHYSICS ABSTRACTS

SECTION A

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SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

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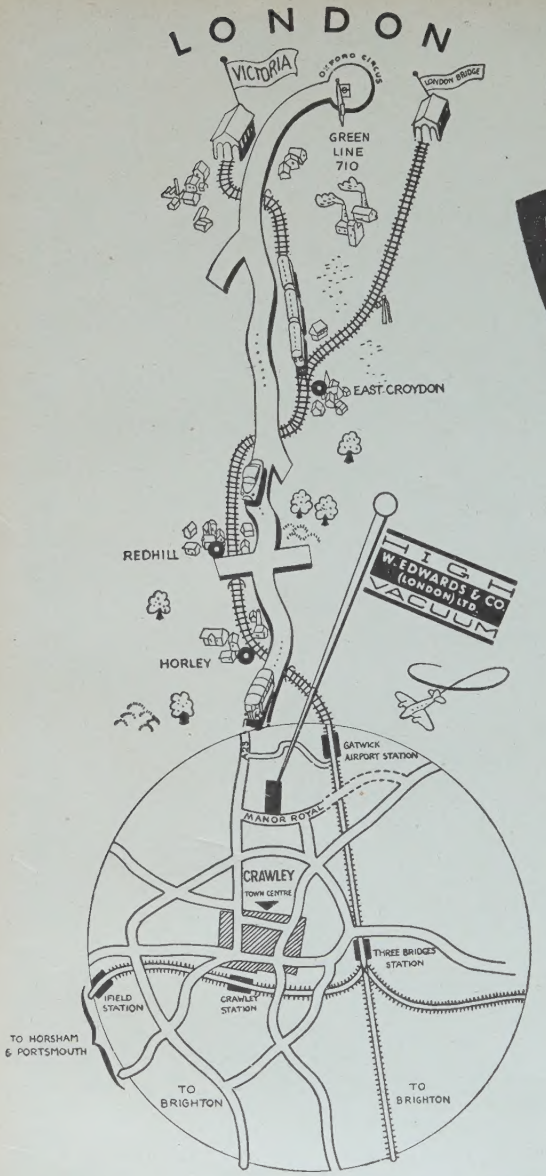

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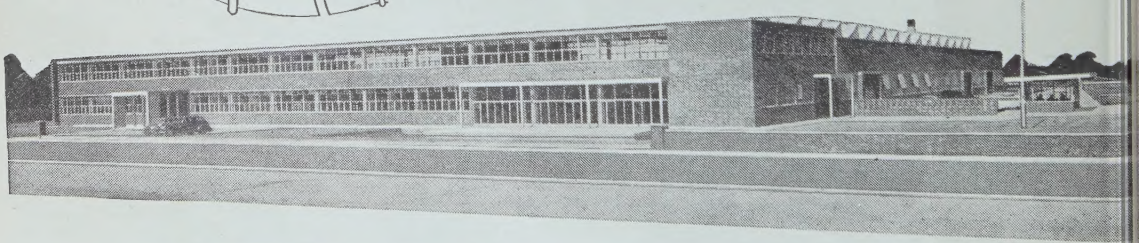

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RELATED SUBJECTS CONTAINED IN SECTION B (ELECTRICAL ENGINEERING ABSTRACTS)

Electrical and magnetic measurements and instruments
Electronic relays and counters
Automatic control mechanisms
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Photocells
Thermionic tubes
Cathode-ray tubes
X-ray tubes
Amplifiers
Radiocommunication
Mechanical engineering
Illumination

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 56 (1953) and the Supplement published with the Index to Volume 53 (1953). Reprints of the List of Journals (1953) and the Supplement (1953) can be obtained from the Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. 0d. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Acta Sci. Sinica	*Acta Scientia Sinica.* Guozi Shudian, 38 Suchou Hutung, Peking.
Circ. Electrotech. Lab. [Tokyo]	*Circulars of the Electrotechnical Laboratory.* Agency of Industrial Science and Technology. Ministry of International Trade and Industry, 2-chome, Nagato-cho, Chiyoda-ku, Tokyo.
Gas Oil Pwr	*Gas and Oil Power.* [Abstracted by Metropolitan-Vickers Electrical Company.]
Mem. Fac. Industr. Arts Kyoto Tech. Univ. (Sci. Technol.)	*Memoirs of the Faculty of Industrial Arts Kyoto Technical University. Science and Technology.* Kyoto Technical University, Matsugasaki, Sakyoku, Kyoto.

New Journal

Optica Acta	*Optica Acta.* Published under the auspices of the International Optical Commission of the International Union of Pure and Applied Physics by Société de la Revue d'Optique, 3 and 5 Boulevard Pasteur, Paris (15e). Parts issued at approximately quarterly intervals; volumes will be made up of 4 to 6 parts. Subscription 3500 francs per volume. Volume I, No. 1 dated January, 1954.

Errata

Author Index (1953) p. 1168, column 1: insert FINN, G. Evaporation of copper from germanium, 8406.

Abstr. 712 (1954) line 5: *for* scalar *read* scaler.

Abstr. 715 (1954) line 6: *for* M_1 *read* M1.

Abstr. 724 (1954) line 4: *for* multiple *read* multipole.

Abstr. 776 (1954) line 5: *for* γ *read* ν.

Abstr. 904 (1954) line 2: *for* 12 *read* 11.

line 8: *for* carved *read* varved.

Corrections to Articles

Corrections have been published, as shown below, to the articles whose abstract numbers are given. Unless otherwise stated, the volume and page given refer to the journal named in the abstract, i.e. the journal in which the original article was published.

Abstr. 2304 (1953): **25**, 1203 (*Nov.*, 1953).

Abstr. 4284 (1953): **24**, 1529 (*Dec.*, 1953).

Abstr. 5352 (1953): **25**, 1202 (*Nov.*, 1953).

Abstr. 6574 (1953): **25**, 1203 (*Nov.*, 1953).

Abstr. 6829 (1953): **24**, 1086 (*Nov.*, 1953).

Abstr. 7088 (1953): **19**, 1034 (*Oct.*, 1953).

MATHEMATICS 51

512.99 : 539.166

A vector addition coefficient identity. *See Abstr.* 1657

517.948 : 517.923

970. Two first-order integral equations which can be solved by means of Mathieu functions. J. DÖRR. *Z. angew. Math. Phys.*, **3**, *No.* 6, 427–39 (1952) *In German.*

These integrals may be reduced to the function $f = AJ_0[k(\cos\alpha - \cos\beta)] + BN_0(k|\cos\alpha - \cos\beta|)$ which has even Mathieu functions as eigenfunctions. The corresponding eigenvalues are found by expanding in the form of a series of Bessel functions and summing numerically. By finding $\partial f/\partial\beta$ an equation is reached which may be solved by means of the eigenvalues obtained as above. The original equation occurs in certain diffraction and oscillation problems. N. CORCORAN

518.5

971. Programme design for an electronic calculator. H. HARMUTH. *Acta phys. Austriaca*, **7**, *No.* 4, 390–401 (1953) *In German.*

The analogy between the Galton pin-table and an electronic computer is elaborated to find the most probable or all possible distributions in the case of a given system of physical statistics. The computer is illustrated by a block schematic; uniselector switches serve as control elements. T. J. REY

518.5

972. Application of digital computing techniques to physics. R. A. BROOKER. *Brit. J. appl. Phys.*, **4**, 321–6 (*Nov.*, 1953).

Some computations likely to occur in connection with physical problems are discussed in relation to electronic computers. General discussion is reinforced by examples taken from the literature, for which figures about programming time, machine running time, etc., are given. Some aspects of machine design are discussed. The training of personnel in the use of electronic computers is noted. A.

518.5 : 164 : 621.374.32 : 621.372

973. Theory of logical nets. A. W. BURKS AND J. B. WRIGHT. *Proc. Inst. Radio Engrs*, **41**, 1357–65 (*Oct.*, 1953).

The aim of this paper is to place on a more rigorous basis the application of two-valued logic to digital computing circuits. The formal properties are studied of various logical nets, some of which represent such circuits to a useful degree. A logical net is an array constructed from two primitive elements: a "stroke element," by means of which circuit components performing logical functions may be represented, and a "delay element," used in the representation of memory components. With each net is associated a set of equations useful in studying the behaviour of that net. Various types of nets (well-behaved, deterministic, well-formed) are precisely defined and properties of each type are correlated with properties of the associated sets of equations. The relations between the various types of nets are investigated and some study is made of the kinds of operations performed by each. Finally, the question: "To what class of nets do digital computer circuits correspond?" is discussed. A.

518.5 : 612.8

974. The principles of a multipole machine in terms of algebraic structure. J. RIGUET. *C.R. Acad. Sci. [Paris]* **237**, 425–7 (*Aug.* 10, 1953) *In French.*

The idea of algebraic structure, as examined by Birkhoff [*Proc. Cambridge Phil. Soc.*, **31**, 433 (1935)], is shown to be applicable to the design of Ashby's machine [Abstr. 2859 (1949)]. Certain consequences of the treatment are briefly indicated. A. J. KENNEDY

518.5 : 66 : 621–5

975. A frequency response analyser for pneumatic process control systems. C. R. WEBB AND D. J. OZANNE. *J. sci. Instrum.*, **30**, 424–6 (*Nov.*, 1953).

A simple and relatively inexpensive instrument is described for use in harmonic response tests on closed-loop process control systems. It is capable of a high degree of accuracy in the measurement of amplitude ratio and phase difference. A.

518.5 : 681.142

976. Computers and automata. C. E. SHANNON. *Proc. Inst. Radio Engrs*, **41**, 1234–41 (*Oct.*, 1953).

This paper reviews briefly some of the recent developments in the field of automata and non-numerical computation. A number of typical machines are described, including logic machines, game-playing machines and learning machines. Some theoretical questions and developments are discussed, such as a comparison of computers and the brain, Turing's formulation of computing machines and von Neumann's models of self-reproducing machines. A.

518.5 : 681.142 : 621.317.79

977. The solution of partial differential equations by difference methods using the electronic differential analyzer. R. M. HOWE AND V. S. HANEMAN, JR. *Proc. Inst. Radio Engrs*, **41**, 1497–508 (*Oct.*, 1953).

Partial differential equations can be approximated by systems of simultaneous ordinary differential equations by replacing one or more of the partial derivatives by the appropriate finite differences. The resulting ordinary differential equations can sometimes be solved directly by an electronic differential analyser employing feedback amplifiers. Both theoretical analysis of the accuracies attainable with the difference method and actual solution examples using the electronic differential analyser are described. Types of partial differential equations considered include the heat, wave, and beam equations. A.

519.24 : 53.081 : 539.154

The basis for the criterion of least squares. *See Abstr.* 1584

519.281.2 : 53.088

978. On the application of the method of least squares in physics. P. VERNOTTE. *C.R. Acad. Sci.* [*Paris*] **237**, 605–6 (*Sept.* 21, 1953) *In French.*

For correct application of the method of least squares to the relationship between the physical phenomena x and y, it is necessary to treat both functions as experimental functions of a parameter t (e.g. time), whose successive values are known exactly, and then eliminate t between $x(t)$ and $y(t)$ to obtain the physical relationship $y(x)$.

H. H. HODGSON

ASTRONOMY . ASTROPHYSICS . GEODESY 52

521.042 : 523.51 : 539.155.2

Concentration of uranium and lead and the isotopic composition of lead in meteoritic material. *See Abstr.* 1589

521.044

979. Side lights on cosmic chemistry. P. W. MERRILL. *Proc. Amer. Phil. Soc.*, **97**, 356–8 (*Sept.* 28, 1953).

A brief historical survey of the relations existing between astronomy and chemistry, leading up to recent studies in the evolution of stellar material. It is emphasized that stellar spectroscopy has enabled our knowledge of cosmic chemistry to be more exact than that of the spatial structure of our own galaxy, and those lying beyond it. D. R. BARBER

522 : 525.7

980. The possibility of compensating astronomical seeing. H. W. BABCOCK. *Publ. Astron. Soc. Pacific*, **65**, 229–36 (*Oct.*, 1953).

Draws attention to the effect of unsteady enlargement and movement of images in astronomical instruments due to turbulence of the atmosphere. The problem of the movement has been solved and this paper suggests a method of compensating for the enlarged images. The principle of the device is to measure the deviations from all parts of the mirror producing the image and to amplify and feed back the information to locally correct the figure in response to the schlieren pattern. Tested for large screen television projection the apparatus depends upon a thin layer of oil covering a reflecting mirror. Using electrostatic forces, the oil film is distorted according to the pattern received from the scanner. The height in the atmosphere of the disturbed region affects the area controlled and the necessity for a bright control star is a further limitation. The suggestion is made to use the apparatus as an optical figure corrector where flexure of the mounting takes place.

E. G. MARTIN

522.613 : 621.396.677

981. A high-resolution aerial system of a new type. B. Y. MILLS AND A. G. LITTLE. *Austral. J. Phys.*, **6**, 272–8 (*Sept.*, 1953).

A method of constructing a high-resolution low-gain aerial system of small area and low cost is described. It consists of two arrays of dipoles arranged in the form of a cross and switched rapidly in and out of phase with each other. The only signals modulated at the switching frequency will be those from regions of the polar diagrams common to both systems. Application at metre wavelengths for radio astronomy investigations is discussed; a small-scale model has been made to test the principle. [See Abstr. 6994 (1952) for application in an interferometer.]

522.615 : 535.215

982. Investigation of a photoelectric photometer, attached to the 100 cm Schaer telescope. M. GOLAY. *Arch. Sci.* [*Geneva*], **6**, *No.* 2, 57–66 (1953) *In French.*

An astronomical photometer is described using unselected photomultiplier cells, and with provision for presenting the measured intensity on an oscillograph or galvanometer, or by the time taken to charge an integrator circuit. There is some discussion of variation in sensitivity across the photocathode, and of the reduction in dark-current resulting from leaving the cell in the dark with normal voltages applied. A. BEER

522.615 : 778.3

Application of non-colour-sensitized photographic emulsions to photographic recording with the electronic telescope. *See Abstr.* 1936

523.12 : 523.87

983. Technetium as a test of cosmological theory. P. JORDAN. Note in *Naturwissenschaften*, **40**, *No.* 15, 407–8 (1953) *In German.*

P. W. Merrill's detection of lines of Tc I in the spectra of *S*-type stars [*Astrophys. J.*, **116**, 21–6 (*July*, 1952)] is claimed as evidence in support of Jordan's theory of stellar formation which regards the building up of elements as a process that can still take place. R. A. NEWING

523.165

984. Fine structure of the extra-terrestrial radio source Cygnus I. R. C. JENNISON AND M. K. DAS GUPTA. Letter in *Nature* [*London*] **172**, 996–7 (*Nov.* 28, 1953).

The distribution of radiation across the Cygnus source has been examined on 125 Mc/s with a variable-spacing interferometer. The variation of correlation function with separation from these observations and those of Smith and Mills [Abstr. 1337 (1953)] gives the Fourier transform of the intensity distribution across the source. The simplest and most compact model giving this transform is that of two emission regions about $51'' \times 30''$ separated by $1'\,28''$. This model is much larger than the visual object with which the source is supposed to be associated (a pair of colliding galaxies), and there is little overlap between the visual and the radio emission patterns.

M. W. OVENDEN

523.165

985. An extended radio-frequency source of extra-galactic origin. R. H. BROWN AND C. HAZARD. Letter in *Nature* [*London*] **172**, 997–8 (*Nov.* 28, 1953).

Observations on 158·5 Mc/s of an extended band of low-intensity radiation lying between 44° and 54° N declination [Abstr. 3210 (1953)] have been extended to the declination range 40° to 70°. This band is

associated with a visually-observed concentration of extra-galactic nebulae. Observations of intensity on 158·5 and 72 Mc/s suggest a radio intensity varying inversely as the square-root of the frequency. A comparison has been made of the observed radio intensity with that to be expected if all galaxies showed the same ratio of radio/light flux as do spirals; the radio flux is $1^{m}.7$ greater than the predicted value. M. W. OVENDEN

523.165 : 537.591

986. Can matter be created out of cosmic radiation? A. K. Das. Note in *Naturwissenschaften*, **40**, *No.* 16, 433–4 (1953).

523.165 : 537.591

Propagation of the cosmic radiation through interstellar space. *See Abstr.* 1436

523.5/.6

987. Comets and meteor streams. J. G. Porter. *London: Chapman and Hall* (1952) *xi* + 123 *pp.* + 6 *plates* [*International astrophysics series. Volume* 2].

Review in *Nature* [*London*] **172**, 883 (*Nov.* 14, 1953).

523.5 : 538.566.2

988. Meteor echo duration and radio wave length. D. W. R. McKinley. *Canad. J. Phys.*, **31**, 1121–35 (*Nov.*, 1953).

The durations of radar echoes from meteors have been observed simultaneously on 9·22 m and 5·35 m and also on 9·22 m and 2·83 m. The ratio of durations on two wavelengths decreases with increasing duration by a factor of two over the observed range, deviating significantly from the accepted square law of wavelength. Plotting the log of the ratio against the log of the duration yields two straight lines of different slopes, one in the short-duration range and the other applying to the longer echoes. General empirical formulae are developed to predict the echo duration on one radio equipment in terms of the duration of the same echo recorded by another apparatus of different sensitivity and wavelength. A.

523.7 : 523.8

989. Astrophysics: the atmosphere of the sun and stars. L. H. Aller. *New York: Ronald Press* (1953) 412 *pp.*

Review in *Science*, **118**, 392 (*Oct.* 2, 1953). "After five introductory chapters discussing in some detail the physical theory used in the last part of the book, the final four chapters discuss in great detail the radiation of the stars, the continuous spectra of sun and stars, the Fraunhofer spectrum, and solar phenomena. The book is well produced and there is an extensive index."

523.72

990. Radio noise-bursts from solar *M*-regions. A. K. Das and B. N. Bhargava. Letter in *Nature* [*London*] **172**, 855–6 (*Nov.* 7, 1953).

Observations are reported of crochet-like disturbances in *H*-magnetograms due to ultraviolet emission from a solar *M*-region, together with associated noise-bursts on 100 Mc/s. Spectroheliograms showed no associated calcium flocculi or hydrogen absorption filaments. M. W. OVENDEN

523.74 : 550.384

Geomagnetic activity and sunspot cycle. *See Abstr.* 1882

523.746

991. Progressive alteration in the form of the sunspot curve. A. Kiral. Note in *Naturwissenschaften*, **40**, *No.* 18, 477–8 (1953) *In German.*

523.752

992. The non-Maxwellian distribution in a shock front and the anomaly of the chromospheric temperature. H. K. Sen. *Phys. Rev.*, **92**, 861–6 (*Nov.* 15, 1953).

An estimate is made of the departure from the Maxwellian distribution of the particle velocities in a shock front, as a function of the shock strength. Expressions are derived for the absorption and emission coefficients (for electronic free-free transitions in a completely ionized gas) in a shock front of given strength. The results obtained are applied to resolve the apparent conflict between the two electronic temperatures of the chromosphere, as indicated by optical (30 000°K from emission line widths) and radio (10 000°K from centimetric radiation intensity) observations of the sun. A.

523.755

993. The solar corona of 25 February, 1952. M. G. Fracastoro. *Mem. Accad. Naz. Lincei*, **4**, *No.* 2, 51–90 (1953) *In Italian.*

Sixteen plates, 8 in the violet, 5 in the green and 3 in the red spectral regions were exposed in the Arcetri coronagraph at Khartoum, and subsequently were reduced by the aid of microphotometer tracings to derive definitive isophotal contours from which the variation of coronal radiation with distance from the solar limb could be deduced. Corrections were applied to the photometry in order to take account of various sources of error. From the combined reductions for each of the above 3 series, isophotal diagrams corresponding to effective wavelengths 4300 Å, 5300 Å and 6400 Å, have been constructed. The variation of the coronal radiation with distance from solar limb, and the colour-index, were measured by the aid of these mean isophotes. The v. minus r. colour-excess amounts to +1·23 mag., cf. an excess of +2·13 mag. on the same photometric scale for an AO-star. D. R. BARBER

523.755

994. The rotation of the solar corona in different latitudes. W. Petri. Note in *Naturwissenschaften*, **40**, *No.* 15, 408 (1953) *In German.*

The empirical law that the outer optically accessible atmospheric layers of the sun rotate faster at the equator than in higher latitudes is examined to see if it can also be applied to the corona. R. Müller [Abstr. 6426 (1953)] denied this, while Waldmeier [Abstr. 6213 (1950)] gave, e.g., for 24° latitude a daily rotation of 13°·9, and for 55° only 13°·1. The author discusses Müller's material, obtained on the Wendelstein during the period 1949–52 on 513 days, and, after a uniform reduction and statistical rearrangements, confirms Waldmeier's view. The slower rotation appears clearly established for latitudes above 30°. The numerical values fit well into those for the solar rotation. Asymmetries between the northern and the southern hemisphere are noted, as well as the existence of definite drift-movements and

of local deviations from a "mean rotation law" for the corona. As physical explanations the views of Schmeidler [Abstr. 8444 (1950)] and Kiepenheuer [Abstr. 736 (1952)] are suggested. The importance of a continuous survey of Doppler motions within the corona is emphasized. A. BEER

523.755

995. Photometric and polarimetric observations of the solar corona during the total eclipse of the sun on Feb. 25, 1952. M. CIMINO. *R.C. Accad. Naz. Lincei*, **15**, 39–44 (*July-Aug.*, 1953) *In Italian.*

523.77

996. Contribution to the physical study of the photosphere and the sunspots. R. MICHARD. *Ann. Astrophys.*, **16**, *No.* 4, 217–86 (1953) *In French.*

Part I (222–46): A study of the continuous spectrum of the sun by the semi-empirical methods of Chalonge and Kourganoff and of Peyturaux. (*a*) Using source functions derived from limb-darkening and absolute-intensity measurements in the infrared and visible ranges, and Chandrasekhar and Breen's calculated absorption coefficients of H^-, six model atmospheres corresponding to various helium and metal abundances are calculated. The character of the continuous spectrum in the neighbourhood of the Balmer discontinuity indicates that the abundance is considerably less than the 18% found by Unsöld. (*b*) The presence of a probable additional source of continuous absorption (apart from H and H^-) in the ultraviolet appears to be important in the outer layers only. (*c*) The model is used to calculate the radiative flux; these values, corrected for line absorption, confirm the existence of a convective zone, the non-radiative component of the flux being 10–15%. (*d*) A study of the line intensities of Fe, Ti and Ti^+ in the green region indicates that the temperature in the outermost layers should be slightly reduced. Methods of determining the helium and metal content of the photosphere from the line spectrum are discussed.

Part II (247–67): Spectra of 30 spots in the range λ3200–6700 have been taken with quartz optics and dispersion 12 Å/mm at various points on the solar disk. Measurements at 6 wavelengths of the ratio I'/I of intensities in spot and photosphere, corrected for scattered light and image tremor, lead to: (1) The relative limb darkening of I and I' for a group of large spots. (2) I'/I as function of λ; I' appears to have a slight Balmer discontinuity; (3) the relation between I' and the spot's area or magnetic field.

Part III (268–85): The source functions at various depths and in various wavelengths along the centre line of a typical spot are deduced from the observations. $\tau_\lambda(T)$ is thus found and indicates that the continuous absorption is due to H^- at least for $\lambda \geqslant 4800$ Å; this result is confirmed by the agreement between the calculated continuous spot spectrum in the infrared and the observations of Pettit and Nicholson. The equivalent widths of Ti, Ti^+ and Fe lines in large spots, measured by ten Bruggencate and von Klüber, are rediscussed. From these lines it is possible to deduce a model atmosphere which gives a complete description of the line spectrum. The model is extended with some uncertainty to greater depths on the basis of the measured Balmer discontinuity: $D = 0{\cdot}015$. The pressure in a spot is found to be much less than in a region of the same geometric depth in the neighbouring photosphere. The model has been used to recalculate the magnetic field gradient under various conditions (following Houtgast and van Sluijters). Theoretical consequences are briefly discussed. A. BEER

523.775

997. Spectroscopic and spectrophotometric observations of the solar corona made at Khartoum, 25 February 1952, by Bernard Lyot assisted by M. Khairy Aly. A. DANJON. *C.R. Acad. Sci.* [*Paris*] **237**, 854–5 (*Oct.* 19, 1953) *In French.*

523.775

998. A study of spectra of the solar corona obtained at Khartoum during the total solar eclipse of 25 February 1952. B. LYOT AND A. DOLLFUS. *C.R. Acad. Sci.* [*Paris*] **237**, 855–9 (*Oct.* 19, 1953) *In French.*

Emission features between wavelength limits, 3000 Å and 6800 Å, found in spectra of one bright prominence, and four coronal jets photographed during totality, have been analysed. The prominence spectrum yielded 262 lines comprising all the normally observed emission lines except 4311 Å; and in addition 4 certain, and 1 doubtful, new emissions. The jet spectra gave a line-intensity distribution within four distinct groups which correspond closely to Edlen's identifications. D. R. BARBER

523.852

999. On the possibility of deducing immediately from the differential Wolf diagram the distance, and the absorbing power of a dark nebula, as well as the dispersion, σ, of the absolute magnitudes. J. WARZÉE. *Mem. Acad. Roy. Belgique Cl. Sci.*, **28**, *No.* 4, 42 *pp.* (1953) *In French.*

On the tacit assumptions that a dark nebula functions as an optical filter, that the function of stellar luminosity distribution fits a Gaussian curve and that the spatial stellar densities conform to Seeliger's law, i.e. $\log A(m) = \alpha + \beta m$, it is shown that the distance, R_c, of the dark nebula may be determined directly from the basic equation, $5 \log R_e = \mu + 5 - (M_0 + \varepsilon/2)$ where M_0 is the mean absolute magnitude, ε the absorbing power of the nebula and μ is the value of the point on the Wolf curve corresponding to max. apparent absorption, ε_μ and to the max. value of the quantity, $\log A(m) - \log A_0(m)$, the suffix referring to the region of obscuration. The relation is quite independent of the dispersion, σ. The method is extended to cover those cases for which ε cannot be derived directly from the Wolf diagram, and a numerical example is included. D. R. BARBER

523.852.21

1000. Polarization of the diffuse nebulae, IC 4601a, IC 4601b and BD-19° 4357. M.-T. MARTEL. *C.R. Acad. Sci.* [*Paris*] **237**, 787–9 (*Oct.* 12, 1953) *In French.*

A continuation of previous work [see Abstr. 7481 (1951)]. The polarigraph used in the original investigation of NGC. 7023 has been redesigned along similar lines to those first proposed by Öhman (1939). Each of the 3 bright nebulae has been triplicated on the photographic plate, corresponding to orientations

of the analyser differing by 45°. For IC 4601a, additional exposures at orientations, 30° and 75° respectively from the W–E axis were made on the same plate. For all three objects the degree of polarization shows marked asymmetry in distribution relative to the exciting star (or stars). D. R. BARBER

523.854

1001. Galactic structure and the distribution of interstellar gas. G. MÜNCH. *Publ. Astron. Soc. Pacific*, **65**, 179–84 (*Aug.*, 1953).

Recent observational data shows that the velocities derived from interstellar lines in northern Milky Way spectra show a systematic dependence on galactic longitude, from which a galactic rotation effect is inferred. The effect is found to vanish for stars in the anticentral region, and to reach a max. value near $l = 100°$, decreasing again to $l = 55°$.

D. R. BARBER

523.855

1002. A test for high latitude absorption as a factor in the distribution of galaxies. H. SHAPLEY. *Publ. Astron. Soc. Pacific*, **65**, 237–41 (*Oct.*, 1953).

The observed unevenness in the distribution of galaxies in low latitudes below $\pm 30°$, attributable to dust clouds in our own galactic system, is associated also with an uneven distribution (due to effective absorption) of the stars in these latitudes. A test for a possible similar correlation of nebular and stellar distributions in high latitudes is discussed in relation to the presence of absorbing clouds, either near the galactic plane or even far out in intergalactic regions. Galaxy and star counts, down to a limiting magnitude, ~18·0, in 8 separate high-latitude areas show clearly that the foregound stellar distribution is essentially smooth; and that the small fluctuations observed are not correlated with the large distributional differences observed for the galaxies. It is concluded that the uneven distribution of galaxies in high latitudes is due, not to an uneven space absorption, but merely to the non-homogeneous structure of the metagalaxy.

D. R. BARBER

523.877 : 532.527

The stability of rotating liquid masses. *See Abstr.* 1097

529.78

1003. The influence of barometric pressure on watch and chronometer rates. N. W. B. STONE, K. W. T. ELLIOTT AND P. H. BIGG. *Brit. J. appl. Phys.*, **4**, 379–82 (*Dec.*, 1953).

Experiments are described in which the rate and arc of a high quality watch and a marine chronometer were observed at a number of pressures from zero to 760 mm of mercury. Lack of isochronism can cause pressure variations to affect watch rates differently at different states of winding or in different positions, but fairly consistent values for the pressure coefficients can be derived if allowance is made for change of arc using the rate/arc relationship observed at normal pressures. The observed pressure variations with constant arc are briefly discussed. A.

529.786

1004. Pendulum clocks, quartz clocks and atom clocks as time standards. A comparison. A. SCHEIBE. Note in *Z. angew. Phys.*, **5**, *No.* 8, 307–17 (1953) *In German.*

The performances of recent forms of standard clocks are discussed and compared. The basic principles of the Shortt, Riefler and Schuler pendulum clocks, the standard quartz clocks at various places in England, France, Germany and U.S.A. and the NH_3 and Cs atomic clocks are briefly described and the constructions illustrated. It is shown that the quartz clocks are superior in performance to the best astonomical pendulum clocks. The rates of the clocks expressed as $g = g_0 + at + bt^2 + ct^3$ are quoted and discussed. A simple parabolic form suffices for the quartz clock; the contributions from the terms at and bt^2 are small so that over large time periods exact time determinations are possible and annual periodic variations of astronomical time can be measured. The NH_3 clock is inferior to a good quartz clock, but the proposed Cs clock should be superior in performance, since a, b, etc. $= 0$ (36 refs.). S. WEINTROUB

PHYSICS 53

53.08

1005. The process of measurement. G. LUDWIG. *Z. Phys.*, **135**, *No.* 5, 483–511 (1953) *In German.*

The usual contention that in quantum mechanics the process of measurement is inseparably bound up with the subjective reception of the measurement result by an observer's consciousness seems to be unjustifiable. An object, if microscopic, when acting on a measuring apparatus (necessarily macroscopic) initiates in it a thermodynamically irreversible process, of which the final state determines the result of the measurement, independent of any subsequent observation by a conscious observer. The ergodic theorem is deduced, and the transition from quantum to classical physics is carried out in order to derive the foundations of thermodynamics. A note draws attention to similar views expressed by P. Jordan.

P. M. DAVIDSON

53.081 : 539.154

Least-squares adjustment of the atomic constants, 1952. *See Abstr.* 1583

53.081.6

1006. A precision measurement at 24 500 volts of the conversion constant λν. G. L. FELT, J. N. HARRIS AND J. W. M. DUMOND. *Phys. Rev.*, **92**, 1160–75 (*Dec.* 1, 1953).

A precision determination of the wavelength in X-units (Siegbahn scale) at the quantum limit of the continuous spectrum from a tungsten-target sealed-off X-ray tube operating under an accurately stabilized and measured applied voltage, $V_H = 24\,498{\cdot}7 \pm 1{\cdot}1$ absolute volts (e.m.u.) is described. This experiment, often loosely described as a measurement of h/e, is, in the present state of our knowledge of the general physical constants, more properly to be referred to as a determination of the conversion constant $V_A\lambda_s$

between X-ray wavelengths and quantum energy in electron volts. If $V_A = V_H + V_w$ is the sum of the absolute applied voltage V_H and the work function V_w of the tungsten cathode emitter and if λ_s is the quantum limit wavelength on the Siegbahn scale expressed in kilo X-units (kX-units), then $V_A\lambda_s = (h/e)c^2(\lambda_g/\lambda_s)^{-1}10^8$, wherein h is Planck's constant in erg sec, e is the electronic charge in absolute c.g.s. electrostatic units, c is the velocity of light in cm sec^{-1}, and λ_g/λ_s is the conversion factor from wavelengths measured on the Siegbahn nominal scale in X-units to absolute wavelengths in milliangstrom units (10^{-11} cm). Using the method of isochromats, the value obtained in this experiment, with the 2-metre focusing curved quartz crystal spectrometer for the monochromator, was $V_A\lambda_s = 12\,370{\cdot}02 \pm 0{\cdot}63$ e.m.u. kX-units, the error $\pm 0{\cdot}63$, a relative error of 51 parts per million being the estimated standard deviation. A comparison with other determinations of this type is given. This value has been used as one of some thirteen precision data of eight different types in DuMond and Cohen's recent least-squares adjustment (November, 1952) to determine the "best" values of five fundamental constants; α, the fine structure constant; c, the velocity of light; e, the electronic charge; N, Avogadro's number; and $\lambda = (\lambda_g/\lambda_s)$, the above mentioned wavelength conversion factor; and to obtain from these a large number of other useful constants. A.

53.088 : 512

1007. Establishment of an algebra of physically observable functions by means of convolution [Faltung] operations. I. Precisions, function complex, point functions, Fourier-transformation of a complex, integro-differential operator. R. HOSEMANN AND S. N. BAGCHI. *Z. Phys.*, **135**, *No.* 1, 50–84 (1953) *In German.*

An observable can be defined in terms only of parameters which are within the range of measurement and which are subject to the measurement and observational errors of the measuring instrument. For a chronometer with range $|t| \leqslant t_m$ and mean error δt it is shown that the observable function $k(t)$ of a process is $\widehat{g_0 h}$, the convolution product of $g_0(t)$, the true expression of the process, and $h(\delta t, t) = \pi^{-\frac{1}{2}}(\delta t)^{-1}\exp[-(t/\delta t)^2]$, the error function. The function complex g of k consists of the collections of functions g_0 which together with h fall within the above ranges and which represent equally the observable k. The members of g are not distinguishable experimentally. In place of a chronometer the process may be analysed by a frequency analyser. The corresponding function K and function complex G of K is derived. The transformations of g into G and the validity of the method by which the g functions can be extrapolated outside the t_m range (and the G functions outside the corresponding ν_m range) are discussed. The many-valued complex of the point functions P in the t and ν spaces, defined as functions which cannot be resolved by the particular error statistics, and their transformations within and outside the error and measurement ranges are described, and the g and G functions discussed as particular cases. Similar relations exist between the three-dimensional physical space x and the crystallographic b-space as between the t and ν spaces. It is shown that by considering the limiting case of zero errors not only is the connection between mathematics and theoretical physics arrived at, but also the basis for operational calculus and the Dirac δ-function, in addition to the proof of the general validity of the convolution (Faltung) and integral theorems of the Fourier transform. The operators F, F^{-1} of the Fourier transformations, the convolutions (Faltungen, symbol $\widehat{\ }$), the integro-differentiation $\widehat{P^{(n)}g}$ and its transformation $[\frac{1}{2}P + 1/(2\pi i\nu)]^{-n}G$, are all useful operators in the new algebra. S. WEINTROUB

53.088 : 519.281.2

On the application of the method of least squares in physics. *See Abstr.* 978

53.089.6 : 621.317.7.089.6

1008. Practical calibration adjustments for apparatus which obeys a theoretical law imperfectly. J. W. HEAD. *Electronic Engng*, **25**, 499–501 (*Dec.*, 1953).

Various empirical methods of adjustment are considered. The nature of the adjustment achieved is fully explained. The object throughout has been to obtain easily a calibration curve which is sufficiently smooth and sufficiently near the observed values to satisfy practical requirements, rather than to find the unique curve which satisfies a least-squares or other mathematical criterion of goodness of fit. A.

FUNDAMENTALS 530.1

530.1

1009. About space-time asymmetry in the realm of classical, general and crystal physics. H. ZOCHER AND C. TÖRÖK. *Proc. Nat. Acad. Sci. U.S.A.*, **39**, 681–6 (*July*, 1953).

530.12

1010. The theory of relativity. Volume II. General relativity theory. [Die Relativitätstheorie. Band II. Die allgemeine Relativätstheorie]. M. v. LAUE. 3rd Ed. *Braunschweig: Vieweg u. Sohn* (1953) 204 *pp.* + *xii.*

Review in *Z. angew. Phys.*, **5**, *No.* 8, 319 (1953) *In German.*

530.12

1011. On the equivalency for observers in the special theory of relativity. Y. UENO. *Progr. theor. Phys.*, **9**, 74–84 (*Jan.*, 1953).

Laying stress on the concept of the equivalency of the observers, the properties of the co-ordinate transformations connecting the observers relatively in uniform motion are investigated. These transformations form the "uniform motion group" together with the frame-transformations of the special forms. The relations between the uniform motion group and the Lorentz group are investigated. A.

530.12

1012. On the group of transformations in six-dimensional space. Y. MURAI. *Progr. theor. Phys.*, **9**, 147–68 (*Feb.*, 1953).

The possible irreducible representations of Lie algebra of the transformation group which leaves the fundamental quadratic form, $(x^1)^2 + (x^2)^2 + (x^3)^2 - (x^0)^2 + (x^5)^2 - (x^6)^2$, invariant, are investigated. Three

invariants which commute with all the elements of the algebra are given and every irreducible representation is characterized by the values of these invariants. A.

530.12

1013. On unified field theories. W. SCHERRER. *C.R. Acad. Sci.* [*Paris*] **237,** 554–5 (*Sept.* 14, 1953) *In French.*

The suggestion is made to take as a starting point for a unified field theory the construction of a n-dimensional linear differential geometry. G. FIELD

530.12 : 523.11

1014. On the properties of an unstable cosmological model containing an "imperfect fluid." R. L. BRAHMACHARY. Note in *Naturwissenschaften,* **40,** *No.* 17, 456–7 (1953) *In French.*

The model considered is such that $T_1^1 \neq T_2^2$. In a disturbed static universe, density and pressure become functions of distance from the origin. R. A. NEWING

530.12 : 530.145

1015. Expectations from a unified field theory. B. KURŞUNOĞLU. Letter in *Phys. Rev.,* **92,** 506 (*Oct.* 15, 1953).

In such a theory constants e, m, etc., would result from quantization, renormalization having no place. An illustration from unified field theory is given. See also Abstr. 1359 (1953). F. ANSBACHER

530.12 : 531.18

1016. A relativistic treatment of rigid body motion. T. MÁTRAI. Letter in *Nature* [*London*] **172,** 858–9 (*Nov.* 7, 1953).

The relative motion of two points P_1, P_2 is said to be rigid if the orthogonal distance of any event on the world line of P_2 from the world line of P_1 is constant. Equations symmetrical in P_1 and P_2 are derived, and the rigid motion of sets of 3 and of 4 points is discussed. It is concluded that the rigid motion of a system of more than 4 points is in general undefinable. R. A. NEWING

530.145

1017. About certain implicit operators giving rise to first integrals. R. FAURE. *C.R. Acad. Sci.* [*Paris*] **237,** 789–91 (*Oct.* 12, 1953) *In French.*

General conditions that operators must fulfil in order to give rise to first integrals (i.e. constants of motion) are discussed. G. E. BROWN

530.145

1018. Note on invariancy of some fundamental equations of physics. M. IKEDA. Letter in *Progr. theor. Phys.,* **8,** 382–3 (*Sept.,* 1952).

The theory of infinitesimal transformations is used to determine the continuous transformation groups which leave invariant the electromagnetic equations and the scalar and vector wave equations. R. A. NEWING

530.145

1019. The theory of the spectrum of mass. R. REULOS. Letter in *J. Phys. Radium,* **14,** 549–50 (*Oct.,* 1953) *In French.*

530.145

1020. Principle of detailed balance in quantum field theory. K. GOTO. Letter in *Progr. theor. Phys.,* **8,** 565–7 (*Nov.,* 1952).

An attempt is made to show that the principle holds rigorously in relativistic quantum field theory. The case of a spinor field under plane reflection, space-, time-, and space-time inversions is taken. G. FIELD

530.145

1021. Lattice-space quantization of a nonlinear field theory. L. I. SCHIFF. *Phys. Rev.,* **92,** 766–79 (*Nov.* 1, 1953).

A method for the approximate diagonalization of certain types of quantum field Hamiltonians is developed which is not limited to weakly nonlinear systems. It consists in omitting the gradient terms in zero order, and diagonalizing the resulting Hamiltonian by replacing the field defined in a continuum space by a field defined in a lattice space. This unperturbed system is equivalent to a countably infinite number of uncoupled nonlinear oscillators, which are then coupled together when the gradient terms are included as a perturbation. The method is applied to the quantization of the classical nonlinear meson theory that was introduced in an earlier paper to provide a qualitative explanation of the saturation of nuclear forces, according to which a positive ϕ^4 term is added to the field Hamiltonian. Although the quantized theory is manifestly noncovariant, it is found that a single-particle solution exists that has an approximately relativistic relation between energy, momentum and rest mass. It turns out to be essential that the lattice constant be kept finite, as all computed physical quantities become meaningless in the continuum limit (in which the lattice constant approaches zero). It is shown that these particles obey Einstein–Bose statistics, and that they scatter from each other. Nucleons are introduced as classical sources for the meson field, and calculations are made on the nucleon isobaric state, interaction of mesons with nucleons and heavy nuclei, and nucleon-nucleon interaction. Most of the results of the earlier classical theory have close counterparts in the present quantized theory. The possibility of extending the method to the quantization of both meson and nucleon fields when they are strongly coupled together is discussed briefly. A.

530.145

1022. The theory of quantized fields. IV. J. SCHWINGER. *Phys. Rev.,* **92,** 1283–99 (*Dec.* 1, 1953).

For Pt III, see Abstr. 7431 (1953). The principal development is the extension of the eigenvalue-eigenvector concept to complete sets of anticommuting operators. With the aid of this formalism a transformation function is constructed for the Dirac field, as perturbed by an external source. This transformation function is enlarged to describe phase transformations and, when applied to the isolated Dirac field, yields the charge and energy-momentum eigenvalues and eigenfunctions. The transformation function describing the system in the presence of the source is then used as a generating function to construct the matrices of all ordered products of the field operators, for the isolated Dirac field. The matrices in the occupation number representation are exhibited with a classification that effectively employs a time-reversed description for negative frequency modes. The last section supplements Pt III by constructing the matrices of all ordered products of the potential vector, for the isolated electromagnetic field. A.

530.145 : 539.153

Relativistic correction to the Lamb shift. *See Abstr.* 1580

530.145

1023. The infrared catastrophes of quantum electrodynamics. K. BAUMANN. *Acta phys. Austriaca*, **7**, *No.* 3, 248–50 (1953) *In German.*

A proof is given, in the *S*-matrix formalism, that infrared catastrophes occurring in calculations of radiative corrections are removed upon adding contributions from processes of scattering with energy loss; these latter contributions are equal in magnitude but opposite in sign to the former for very small photon energy k where the processes individually give divergent results. For small k general expressions for both types of processes are given. G. E. BROWN

530.145

1024. Coupled-field Green's functions. J. G. VALATIN. Letter in *Phys. Rev.*, **92**, 522 (*Oct.* 15, 1953).

A preliminary account of a procedure for avoiding all reference to divergent quantities in the equations for the Green's function of quantum electrodynamics by extending the idea of the limiting process introduced by Dirac [*Proc. Cambridge Phil. Soc.*, **30**, 150–63 (*April* 30, 1934)] and Heisenberg [*Z. Phys.*, **90**, *No.* 3–4, 209–31 (*Aug.* 10, 1934)]. P. M. DAVIDSON

530.145

1025. Theory of line-breadth phenomena. E. ARNOUS AND W. HEITLER. *Proc. Roy. Soc. A*, **220**, 290–310 (*Dec.* 8, 1953).

A general and exact formalism is developed that permits the calculation of the line shape in all line-breadth phenomena, in principle to any order of approximation. Expansions for the line breadth and the numerator occurring in the line-shape formula are given. Corrections to the classical line shape include: (i) radiative corrections to the line breadth, (ii) a level shift additional to the usual radiative shift for levels with finite transition probability, (iii) radiative corrections to the numerator and (iv) a slight frequency dependence of the numerator. All these corrections, with the exception of (iv), are exceedingly small. The case of radio-frequency transitions is discussed. A.

530.145

1026. A note on the gauge transformation in the theory of non-local interaction of the fields. S. OZAKI, S. NAGATA AND Y. OKAMURA. Letter in *Progr. theor. Phys.*, **8**, 574–6 (*Nov.*, 1952).

It is found that the Lagrangian of the form suggested by Møller and Kristensen [Abstr. 2196 (1953)] is not gauge invariant for the case of Dirac particles interacting with the electromagnetic field. G. FIELD

530.145

1027. Note on the tensor interaction in triplet odd states. S. O-NUMA. Letter in *Progr. theor. Phys.*, **8**, 576–7 (*Nov.*, 1952).

On the basis of p-wave phase-shift calculations it is claimed that a charge-independent static potential is unable to account consistently for p-p and n-p experimental data. G. FIELD

530.145

1028. On Yukawa's theory of non-local field. II. The interaction of non-local fields. O. HARA AND H. SHIMAZU. *Progr. theor. Phys.*, **9**, 137–46 (*Feb.*, 1953).

For previous part see Abstr. 5098 (1951). The self-energy of a local spinor particle interacting with a non-local scalar field is calculated in the second-order approximation of the coupling constant. The result agrees with that obtained from the local theory except for a meaningless constant factor. The result is compared with those of Yennie and of Rayski, and it is pointed out that such an agreement is a direct consequence of the quantization rule adopted by Yukawa. The general feature of the Yukawa's *S*-matrix is discussed, and it is shown that it reduces to the ordinary Dyson's *S*-matrix in the limit when the particle radius tends to zero. The appendix contains a calculation of the vacuum energy of a system composed of two non-local scalar fields mutually interacting. A.

530.145

1029. On the non-local interaction and on the statistical interpretation of the cut-off operators. G. WATAGHIN. Letter in *Nuovo Cimento*, **10**, 500–3 (*April*, 1953).

An approximate description of non-local interactions is given, starting from a local Hamiltonian formalism and using covariant interaction representation. A statistical interpretation of the spin- and charge-dependent "cut-off" factors [Abstr. 4124 (1952)], modifying the Hamiltonian in the Schrödinger representation, would seem to lead to an equation determining the possible masses of elementary particles. G. FIELD

530.145

1030. The Green's function method for strongly interacting particles. M. NEUMAN. *Phys. Rev.*, **92**, 1021–2 (*Nov.* 15, 1953).

The Green's function method is adapted to the description of strongly interacting particles which become more loosely bound as their number increases. A.

530.145

1031. Note on the beta interaction. R. FINKELSTEIN AND P. KAUS. *Phys. Rev.*, **92**, 1316–19 (*Dec.* 1, 1953).

It is shown that the most general Lorentz-invariant interaction between four mutually anticommuting fields leads to matrix elements of the form $(S - T + P)f_1(n, m) + (V - A)f_2(n, m) + (S - A - P)f_3(n, m)$. In the charge-exchange order, neutron and muon decay are compatible with $f_2 = f_3 = 0$; charged pion decay appears to correspond to $f_1 = f_3 = 0$. It is noted that the hypothesis of the same interaction between all fermions does not imply that f_1, f_2 and f_3 are numerical constants; it is possible that they are functions of new variables (n, m) needed to characterize the associated Feynman diagrams: n indicates the number of particles produced in the reaction and m the number of particles minus antiparticles. One can make a simple choice of the f_1 in such a way that the interaction is sometimes $S - T + P$, sometimes $V - A$ and never $S - A - P$. A.

530.145

1032. On the Fierz–Pauli equation for particles of spin 3/2. K. K. GUPTA. *Proc. Indian Acad. Sci. A*, **35**, 255–64 (*May*, 1952).

By comparing the Fierz–Pauli equations with the Bhabha equation $(p_k\alpha^k + \chi)\psi = 0$ [Abstr. 56 (1950)] the 16×16 matrices α^k are written down explicitly and their commutation relations and other properties obtained. G. FIELD

530.145

1033. Intrinsic magnetic moment of elementary particles of spin $\frac{3}{2}$. F. J. BELINFANTE. *Phys. Rev.*, **92**, 997–1001 (*Nov.* 15, 1953).

Fierz–Pauli's theory of spin-$\frac{3}{2}$ particles has been reformulated in a manner somewhat resembling the usual formulation of Dirac's equation for the electron. The discussion is simplified by complete reduction of the representation of the spatial rotation and reflection group by the field. The dependent variables can then be expressed in terms of the spin-$\frac{3}{2}$ field. The magnetic moment and the gyromagnetic ratio of "bare" spin-$\frac{3}{2}$ particles of charge q and mass m are found to be $(q\hbar/2mc)$ and $(q/3mc)$, respectively. A.

530.145

1034. Are there excited states of elementary particles? (Bilocal quantum theory of the electron.) E. BAGGE. *Z. Phys.*, **135**, *No.* 5, 558–72 (1953) *In German.*

In order that the spin of a particle may have more than one value, additional "inner" degrees of freedom are postulated and the resulting eigenvalue equation of a scalar two-body problem is studied. W. A. HEPNER

530.145

1035. An algebraic treatment of the many electron problem. H. NAKANO. *Progr. theor. Phys.*, **9**, 33–73 (*Jan.*, 1953).

The algebraic structure of the Hamiltonian of the many-electron system is studied. Based upon the second quantization scheme, a purely algebraic-theoretical method is established in order to determine the total energies of the many-electron system, where each energy eigenstate of one electron in the Hartree–Fock field of these electrons is occupied by a given number of electrons. This occupation number is either 0, 1 or 2, because of the value, 1/2, of the electron spin. Only the part of the Hamiltonian related to the singly-occupied states is found to be algebraically important, and in relation to it the so-called exchange algebra emerges. The general principle of its manipulation is stated, and some cases of a few numbers of singly occupied states are worked out. In the case that the energy eigenstates of the Hartree–Fock field have degeneracies, the theory so far mentioned does not suffice and more detailed and somewhat complicated study is required. A.

530.145

1036. An introduction to spinors. W. L. BADE AND H. JEHLE. *Rev. mod. Phys.*, **25**, 714–28 (*July*, 1953).

A very clear exposition of the subject, more elementary than the expositions in the original literature. P. M. DAVIDSON

530.145

1037. On Huygens' principle in Dirac's theory of the electron. P. VAN LOC. *C.R. Acad. Sci.* [*Paris*] **237**, 649–51 (*Sept.* 28, 1953) *In French.*

A generalized Kirchhoff formula for the Dirac wave function is derived. G. FIELD

530.145

1038. A geometric approach to nonrelativistic spin theory. W. T. PAYNE. *Amer. J. Phys.*, **21**, 621–8 (*Nov.*, 1953).

The requirements that must be satisfied by a non-relativistic theory of electron spin are examined, and it is shown, with the aid of elementary spinor theory, that these requirements can be met by a geometric scheme whose main operation is the reflection of spinors in an axis. This yields a kind of picture of electron spin. The analytical formulation of the geometric scheme is developed, and is identical with the Pauli spin theory. The part played by non-stationary spin states in the geometric scheme is discussed. A.

530.145

1039. Isotopic spin and new unstable particles. M. GELL-MANN. Letter in *Phys. Rev.*, **92**, 833 (*Nov.* 1, 1953).

It is suggested that the new unstable particles are fermions with integral isotopic spin or bosons with half-integral isotopic spin. Some resulting selection rules are discussed. P. T. MATTHEWS

530.145

1040. Note on a paper by K. H. Tzou. J. B. HUGHES. Letter in *Phil. Mag.*, **44**, 1300–2 (*Nov.*, 1953).

See Abstr. 3761 (1949). Tzou introduces a relativistic modification of Heisenberg's equation and obtains results on the motion of a free electron, which are stated as showing some deviation from those obtained by Dirac using a non-relativistic equation. The present note shows that the results are equivalent. L. S. GODDARD

530.145

1041. A note on the *S*-matrix in the theory of the non-local interaction. T. OUCHI. Letter in *Progr. theor. Phys.*, **8**, 253–4 (*Aug.*, 1952).

Rayski's expression for the self-energy of an electron in a radiation field [Abstr. 764 (1952)] is shown to converge on application of a regularization procedure. G. FIELD

530.145

1042. The equation of motion of a spinning particle in a meson field. R. C. MAJUMDAR, S. P. PANDYA AND S. GUPTA. Letter in *Progr. theor. Phys.*, **8**, 670–2 (*Dec.*, 1952).

The equations of motion of a particle in neutral scalar and vector meson fields are obtained by an extension of Wheeler and Feynman's action-at-a-distance theory. G. FIELD

530.145

1043. Statistics of virtual mesons. G. EDER. *Acta phys. Austriaca*, **7**, *No.* 3, 278–82 (1953) *In German.*

The application of Bose–Einstein statistics to virtual mesons in higher-order interactions between two

nucleons leads to a potential which is finite at the origin. Similarly, for the Møller interaction between two electrons, the case of virtual photons leads to a potential which is also finite at the origin and goes over into the Coulomb potential for distances large compared with the electron radius. The self-energies in both cases are finite. G. FIELD

530.145

1044. Normalization of constants in quantum theory. E. C. G. STUECKELBERG AND A. PETERMANN. *Helv. phys. Acta*, **26**, *No.* 5, 499–520 (1953) *In French with English summary*, 250 *words*.

The expansion of the $S[V]$-matrix depends on the arbitrary constants c_l introduced in earlier papers [see Abstr. 3781 (1950), 6728 (1951)]. The normalization group of infinitesimal operations $P_l = (\partial/\partial c_l)_{c=0}$ is discussed, in particular the restrictions imposed on it by requiring the invariance of S with respect to gauge transformations and to the group expressing the equivalence of pseudoscalar and pseudovector coupling in pseudoscalar theory. G. FIELD

530.145

1045. The general theory of the interaction representation. I. The local field. Y. TAKAHASHI AND H. UMEZAWA. *Progr. theor. Phys.*, **9**, 14–32 (*Jan.*, 1953).

The general relation between the covariant commutation relation and the Green function of the field equation is given. This relation can be easily applied to find the commutation relation of the free field. With the help of this relation the general quantization theory for the system involving the general fields is developed. Moreover, it is proved that the normal dependent term has no effects on the S-matrix and on the expectation values of the physical quantities. A.

530.145

1046. A covariant non-adiabatic equation for nucleon-pion scattering. S. FUBINI. Letter in *Nuovo Cimento*, **10**, 851–4 (*June*, 1953).

See Abstr. 8235 (1953). A covariant integral equation for the Feynman kernel for nucleon-pion scattering is suggested in which all Feynman graphs with a single nucleon line and not more than two pions are included at any one time. The divergence difficulties arising in the Tamm–Dancoff non-adiabatic treatment are eliminated here. G. FIELD

530.145

1047. Pure pseudoscalar theory of meson production. J. MCCONNELL. *Proc. Roy. Irish Acad. A*, **55**, *No.* 11, 169–82 (*July*, 1953).

The meson production cross-section in nucleon-nucleon collisions is calculated for incident nucleons of energy 3 BeV and for pseudoscalar mesons with pseudoscalar coupling. The Weizsäcker–Williams method is used to decompose the meson field of the incident nucleon and the remainder of the problem is that of the scattering of these incident mesons by the other nucleon. The cross-section depends on both the coupling $g^2/\hbar c$ and the minimum value of the impact parameter for the nucleon-nucleon collision. If the latter is taken to be the nucleon Compton wavelength, reasonable results are obtained with $g^2/\hbar c = 4$. G. E. BROWN

530.145

1048. Applicability of the Weizsäcker–Williams method to meson fields. J. MCCONNELL. *Proc. Roy. Irish Acad. A*, **55**, *No.* 11, 183–94 (*July*, 1953).

The calculation is carried out for production of pseudoscalar π-mesons by a nucleon-nucleon collision as in the preceding abstract, but here only energies >12 BeV are considered. The cross-section obtained for large energies agrees with the perturbation theory result in charged theory and a proton-neutron collision, but in a charge symmetrical theory and in a charged theory and a proton-proton collision the results disagree with those of perturbation theory. G. E. BROWN

530.145

1049. On a new theory of particles of arbitrary spin and its application to Coulomb scattering cross-sections. G. PETIAU. *J. Phys. Radium*, **14**, 501–9 (*Oct.*, 1953) *In French.*

A general theory is presented in which an irreducible set of wave equations represents a particle of arbitrary spin, but a single value of the rest mass. A general formula is given for the Coulomb scattering cross-section of two particles of spin $n\hbar/2$ and $m\hbar/2$. P. T. MATTHEWS

530.145

1050. Recoil corrections in strong coupling meson theory. G. WENTZEL. *Phys. Rev.*, **92**, 173–7 (*Oct.* 1, 1953).

For the one-nucleon problem in the neutral *PS–PS* theory, a strong coupling method is developed which in the limiting case of a static nucleon reduces to the conventional *PS–PV* strong coupling theory for mesons in p states, and to the scalar pair theory for mesons in s states. While retaining the non-relativistic cut-off procedure, the method allows correction of the theory for nuclear recoils of non-relativistic order. One of these correction terms gives rise to a d phase-shift in meson-nucleon scattering, besides the s and p phaseshifts obtained already in the static approximation. Some comments on the charge-symmetric theory are added in the final discussion. A.

530.145

1051. Scattering of mesons by complex nuclei. W. W. WADA. *Phys. Rev.*, **92**, 152–5 (*Oct.* 1, 1953).

The results of the previous calculation [Abstr. 629 (1953)] on the scattering of mesons by a single nucleon has been extended to the case of multiple scattering by nucleons in nuclear matter. Methods familiar in the dispersion theory in physical optics are used, and the index of refraction of meson wave has been formally calculated. The absorption and diffraction scattering cross-sections are computed and relation with the results of the recent experimental observation is discussed. A.

530.145

1052. Strong coupling theory of meson scattering. A. N. KAUFMAN. *Phys. Rev.*, **92**, 468–81 (*Oct.* 15, 1953).

The strong coupling theory of meson scattering by nucleons is extended to second order in the inverse of the coupling parameter g for the case of a charged scalar field. The ordinary and charge exchange scattering amplitudes for positive and negative

mesons are calculated by a perturbation expansion in g^{-1}, in terms of the normal modes of the g^0-order Hamiltonian, taking into account the inelasticity caused by the existence of isobaric levels of the compound nucleon. A.

530.145

1053. Some applications of the formalism of the evolution operator. A. VISCONTI. *J. Phys. Radium*, **14**, 591–603 (*Nov.*, 1953) *In French.*

Extending previous work [Abstr. 4924 (1952)] the formalism is employed to obtain a theory of the *S*-matrix, to deduce variational principles for calculating transition probabilities, and to obtain a theory of damping, assuming, in all cases, that the interaction or the perturbation is an explicit function of time. P. M. DAVIDSON

530.145

1054. Convergence of the adiabatic nuclear potential. II. A. KLEIN. *Phys. Rev.*, **92**, 1017–20 (*Nov.* 15, 1953).

A conjecture made in a previous paper [Abstr. 7458 (1953)] concerning the non-convergence of the series of adiabatic nuclear potentials for meson pair theory obtained by means of perturbation methods is shown to be incorrect. The correct series is derived and summed and is in agreement with a result given previously by Wentzel. The same methods suffice for the derivation and summation of two additional series of potentials of the pseudoscalar theory with pseudoscalar coupling. One of these has as its leading term the one-pair potential of fourth order, and the other begins with the leading term of sixth order. Each series has the same radius of convergence which is determined by the condition $xe^x > 2\alpha$, where x is the separation of the nucleons in units of the meson Compton wavelength and $\alpha = (g^2/4\pi)(\mu/2M)$. With $(g^2/4\pi) = 15$, perturbation theory converges for $x > 0{\cdot}85$; with $(g^2/4\pi) = 10$, for $x > 0{\cdot}57$. The convergence of $x \lesssim 1$ is in any case very slow for these values of the coupling constant. The possibility remains that for substantially smaller values of the coupling constant, as are suggested by the inclusion of radiative corrections, perturbation calculations of adiabatic potentials may yield a meaningful first approximation when used in conjunction with a suitable cut-off. A.

530.145

1055. Nuclear forces in pseudoscalar meson theory. K. A. BRUECKNER AND K. M. WATSON. *Phys. Rev.*, **92**, 1023–35 (*Nov.* 15, 1953).

The nuclear forces in pseudoscalar meson theory are evaluated using a nonrelativistic approximation to the relativistic interaction. The potential is obtained in a form which allows explicit evaluation of the contribution due to the multiple scattering of the virtual mesons between the two nucleons. An approximate expression for the potential, including the multiple scattering of a single meson, is obtained in closed form. For $r < 0{\cdot}5\hbar/\mu c$, the multiple-scattering terms predominate and a power series expansion of the potential is non-convergent. On the other hand, for $r > 0{\cdot}5\hbar/\mu c$ the potential obtained can be approximated by the second- and fourth-order terms as obtained from perturbation theory. With these latter two terms and a phenomenological "repulsive core," quite satisfactory results are obtained for the low-energy properties of the two-nucleon system. A.

530.145

1056. Nuclear forces from *P*-wave mesons. E. M. HENLEY AND M. A. RUDERMAN. *Phys. Rev.*, **92**, 1036–44 (*Nov.* 15, 1953).

The nucleon-nucleon potential from meson exchange is related to a matrix describing the scattering of virtual and real mesons by nucleons. This meson-nucleon scattering matrix is calculated for *p*-wave mesons, using the model of Chew, which approximates experimental phase shifts for real mesons. The corrections to the g^2 and g^4 perturbation theory nuclear forces are evaluated. States involving the simultaneous existence of three or more mesons, none of which are absorbed by the same nucleon that emitted them, have been omitted in this treatment. Comparison of these and other results implies that this neglect is unjustified. A.

530.145

1057. The Universal Fermi Interaction. E. J. KONOPINSKI AND H. M. MAHMOUD. *Phys. Rev.*, **92**, 1045–9 (*Nov.* 15, 1953).

On the basis of the hypothesis that the same form of interaction acts among any spin-$\frac{1}{2}$ particles, it is interesting to apply the interaction law found for β decay to the muon processes. The application is beset by two types of ambiguity. The first is due to the uncertainty in measured values of coupling constants, and particularly their signs. The second arises from the various ways in which the correspondence between the particles of μ and β decay may be taken. Arguments are presented that the unique correspondence established if two like neutrinos are ejected in μ decay is the correct one. It is argued that previous interpretations of the Universal Fermi Interaction have been unjustifiably broad. Only processes in which two normal-particles (*vs* anti-particles) are annihilated, and two created, should be expected. The positive muon must be treated as the normal-particle (if the neutron, proton and negatron are) in order to avoid the expectation that muon capture by a proton may yield electrons, contrary to experimental facts. The conclusion that two like neutrinos are ejected in μ decay follows immediately. A.

530.145

1058. Two-body scattering at low-energy. B. ROTH. *Phys. Rev.*, **92**, 1250–2 (*Dec.* 1, 1953).

A series expansion in k is derived for the scattered wave $f(\theta)$ in a short-range field. All angular momentum waves are treated. The "shape-independent approximation" formula is derived from this series, and limits on its validity are given. It is shown that for large scattering lengths one must use the series for $k \cot \delta$; for small scattering lengths, the series for f must be used. A.

530.145

1059. Semiclassical methods in meson processes. J. A. THIE. *Phys. Rev.*, **92**, 1282–3 (*Dec.* 1, 1953).

Simple calculations analogous to the electrodynamical Weizsäcker–Williams method have been carried out for pseudoscalar mesons with pseudoscalar

coupling. By integrating a fast nucleon's virtual meson spectrum with the appropriate meson scattering cross-section, a nucleon–nucleon cross-section is obtained. Results are given for neutron–proton bremsstrahlung and nucleon–nucleon meson production. When comparison is possible, results obtained by this method agree approximately with more exact calculations. A.

530.145 : 539.18

1060. The elastic scattering of particles by atomic nuclei. N. C. Francis and K. M. Watson. *Phys. Rev.*, **92**, 291–303 (*Oct.* 15, 1953).

The description of the elastic scattering of particles by atomic nuclei in terms of the optical model is studied. It is shown that the optical model does not represent only an approximation to the many-body problem, although the optical model potential must in general be considered to contain spin-orbit couplings. An explicit expression is obtained for the optical model potential in terms of the amplitudes for scattering of the incident particle by the individual neutrons and protons of the nucleus. The potential also depends upon correlations in the positions of the nuclear particles. A calculation of the parameters of the optical model seems to be in good agreement with some meson scattering experiments. A.

530.145 : 548.7

1061. Interaction of a nonrelativistic particle with a scalar field with application to slow electrons in polar crystals. T.-D. Lee and D. Pines. *Phys. Rev.*, **92**, 883–9 (*Nov.* 15, 1953).

A general variational technique is developed to study the effect of recoil on the motion of a nonrelativistic particle in a scalar field. The ground state energy is determined, and the results obtained are shown to be exact in the limit of both weak and strong field-particle coupling. This method is applied to investigate the low-lying energy levels of a conduction electron in a polar crystal. The ground-state energy and effective mass so obtained are shown to be in good agreement with the results of Lee, Low, and Pines for the intermediate coupling strengths occurring in real polar crystals. A.

530.145

1062. On the solution in integral series of the wave equation with Yukawa potential. K.-G. Fogel. *Comment. phys.-math.* [*Helsinki*] **16**, *No.*11, 8 *pp.* (1952).

In an earlier paper [Abstr. 6300 (1952)] the author has treated the S-eigensolutions for the Yukawa potential by a method originally due to Jost (1947). The lowest eigenvalue was determined for zero-energy. The result obtained suggested an investigation of the eigenfunctions for $l \neq 0$. The problem has also been treated by Jost and Pais (1951) in connection with scattering. In the present paper the method of Abstr. 6300 (1952) is generalized to include non-vanishing angular momenta. When determining the zero-energy eigenvalues, the procedure used in the previous paper proved to give a very poor convergence order when $l \neq 0$. A.

530.145

1063. Linear meson wave equation in de Sitter space. S. A. Raje. Letter in *Progr. theor. Phys.*, **8**, 384–5 (*Sept.*, 1952).

The equation, in β-matrix formalism, is set up analogously to Dirac's equation for an electron in de Sitter space. The current vector and energy-momentum tensor are determined and the second-order wave equation derived. G. FIELD

530.145

1064. On the meson wave equation in de Sitter space. K. Goto. Letter in *Progr. theor. Phys.*, **8**, 672–5 (*Dec.*, 1952).

The general wave equation for particles of arbitrary spin [Abstr. 39 (1953)] is shown to include Raje's equation as a special case (see preceding abstract). G. FIELD

530.145

1065. Calculation of perturbations from approximate unperturbed wave functions. A Rahman. *Bull. Acad. Roy. Belgique Cl. Sci.*, **39**, *No.* 2, 186–95 (1953).

The circumstances under which a perturbation calculated on the basis of approximate unperturbed wave functions can be greater or less than its true value have been investigated. It is shown that the absolute value of the percentage error in the perturbation so calculated will be less than three times that in the square of the approximate wave function at a point where the function is at its worst. A convergent process has been investigated for the improvement of approximate wave functions already available; the restrictive boundary conditions under which this process is applicable are given together with a simple example where such conditions are satisfied. A.

530.145

1066. On the stability, in the sense of Th. De Donder, of the laws of wave mechanics. H. De Sloovere. *Bull. Acad. Roy. Belgique Cl. Sci.*, **39**, *No.* 3, 336–9 (1953) *In French.*

The laws are shown to be stable, in De Donder's sense. The stability is demonstrated by means of a theorem in the calculus of variations. L. S. GODDARD

530.145

1067. Rigorous solutions of many-particle problems. K. Wildermuth. *Acta phys. Austriaca*, **7**, *No.* 3, 299–310 (1953) *In German.*

Two wave equations, each involving a particle bound on an infinitely heavy source and a second particle incident on the system, are solved exactly. In the first case the two particles are considered to be distinguishable; in the second, indistinguishable. One-dimension is introduced for each particle and interactions of a delta-function type, suitably modified when the singularities introduced by them are too great, are considered. G. E. BROWN

530.145

1068. Conformal transformations in wave mechanics. R. Faure. *C.R. Acad. Sci.* [*Paris*] **237**, 603–5 (*Sept.* 21, 1953) *In French.*

It is shown that by using conformal transformations the proper values of certain plane fields may be related. Examples are the oscillator, and the system consisting of an electron, attracted by a proton, and moving in a plane. L. S. GODDARD

530.145

1069. The virial theorem for Dirac's equation. N. H. March. *Phys. Rev.*, **92**, 481 (*Oct.* 15, 1953).

A general discussion is given of the form of the

virial theorem when Dirac's equation is obeyed. The result reduces to that found by Fock when, as for example in the case of the hydrogen atom, the wave function tends to zero at infinity. With other boundary conditions, however, an additional term arises, which has not been considered hitherto. A.

530.145

1070. Solution of perturbation equations. III. Expression of the constants of transition. M. F. DE LA RIPELLE. *C.R. Acad. Sci.* [*Paris*] **237**, 874–6 (*Oct.* 19, 1953) *In French.*

For Pt II, see Abstr. 4620 (1953). Consideration of transitions by way of a number of intermediate states is continued, and explicit forms for the transition probability are given. In the case where some of the intermediate states are identical, reductions can be performed. G. E. BROWN

530.145

1071. On the elimination of hidden variables in a physical theory. P. DESTOUCHES-FÉVRIER. Letter in *J. Phys. Radium*, **14**, 640 (*Nov.*, 1953) *In French.*

It is maintained that such elimination from an objective deterministic theory would necessarily result in an indeterministic theory possessing the same structure as quantum mechanics. R. A. NEWING

530.145 : 548.7

1072. The crystal momentum as a quantum mechanical operator. E. N. ADAMS II. *J. chem. Phys.*, **21**, 2013–17 (*Nov.*, 1953).

The Schroedinger equation for a particle moving in a perturbed periodic potential is transformed into a representation called the "crystal momentum representation." It is shown that by use of this representation previous approximate "effective mass" equations can be readily derived and extended to arbitrarily high approximation. A theorem concerning weak space-dependent perturbations is discussed. A.

530.145

1073. Electromagnetic mass and a particle model in Darling's theory of elementary particles. H. FREISTADT. *Phys. Rev.*, **92**, 1015–16 (*Nov.* 15, 1953).

A description of a particle in Darling's theory of elementary particles by wave functions of the form $H_1^{(1)}(\kappa s)\kappa s$ and $H_1^{(2)}(\kappa s)/\kappa s$ [$H_1^{(1)}(x)$ is the Hankel function of the first kind of order 1, $s^2 = c^2t^2 - r^2$, $\kappa = m_0c/\hbar$] is discussed. It is shown that no current-charge density described by a conventional interpretation of these wave functions can exist. Hence, the classical interaction $j^\alpha A_\alpha$ associated with these wave functions cannot account for the empirical correction for electromagnetic mass previously used by the author. A.

530.145

1074. Reduction of relativistic two-particle wave equations to approximate forms. II. Z. V. CHRAPLYVY. *Phys. Rev.*, **92**, 1310–15 (*Dec.* 1, 1953).

For Pt I, see Abstr. 6486 (1953). The method of reduction of two-particle relativistic wave equations (an extension of the Foldy–Wouthuysen method), as given in Pt I, was applicable only if $m_I \neq m_{II}$. Other variants of the procedure, free from this restriction, are developed now. On the basis of a discussion of properties of the matrices involved, it is found that the postulate of an "even-even" transformed Hamiltonian was too far-reaching. The less stringent requirement of a "uU separating" or an "lL separating" $\mathcal{H}_{tr}$ leads to a whole class of usable transformations, which includes the transformation of Pt I as a special case. Another important special case (that of the "least change" transformation) has been calculated through in detail. Different transformations give different expressions for $\mathcal{H}_{tr}$, but they coincide after (as a part of the next step of the procedure) the matrices β^I and β^{II} are replaced by I (or -1). Consequently the reduced wave equation is the same in all cases. A.

530.162

1075. The Brownian movement of linear and non-linear systems. D. K. C. MACDONALD. *Phil. Mag.*, **45**, 63–8 (*Jan.*, 1954).

It has not so far proved possible to extend the conventional Brownian movement analysis to a system with an intrinsically non-linear relaxation mechanism (e.g. viscosity or electrical conductivity). In this paper a new statistical hypothesis is proposed which for the ideally linear circuit yields results in agreement with those already accepted and enables a calculation to be made of the Brownian movement (and corresponding frequency-spectrum) of a non-linear system. The results may be of interest in a number of practical problems, particularly in relation to proposals for the use of electrical "noise" as an absolute thermometer at high temperatures. A.

530.162

1076. Note on the theory of Brownian motion in non-linear systems. D. POLDER. *Phil. Mag.*, **45**, 69–72 (*Jan.*, 1954).

The hypothesis advanced in the preceding abstract is shown to lead to a contradiction. It is indicated how a formalism developed by Kramers may be used in this connection. A.

530.162 : 533.7 : 536.7

1077. Lectures on theoretical physics. Volume 5. Thermodynamics and statistics. [Vorlesungen über theoretische Physik. Band 5. Thermodynamik und Statistik]. A. SOMMERFELD. *Wiesbaden: Dieterich'sche Verlagsbuchhandlung* (1952) *xiv* + 374 *pp.*

Review in *Proc. Phys. Soc.* [*London*] *A*, **66**, 1197 (*Dec.*, 1953). "This book completes the series of six volumes containing the lectures which Sommerfeld used to give to his students. The present volume deals with thermodynamics, kinetic theory and statistical mechanics."

530.162 : 536.75

1078. Bounds for entropy. N. M. BLACHMAN. Letter in *J. appl. Phys.*, **24**, 1340 (*Oct.*, 1953).

Five bounds are presented for the entropy integral of information theory. T. J. REY

GENERAL MECHANICS . MECHANICS OF SOLIDS 531

531.2

1079. Linear elastic stability. A critical analysis of methods. II. H. ZIEGLER. *Z. angew. Math. Phys.*, **4**, *No.* 3, 167–85 (1953).

Applications of the analysis given in Pt I [Abstr. 6496 (1953)] illustrating the limitations of purely static

methods of calculating modes of instability. Critical speeds of shafts are determined by a kinetic analysis.

J. G. OLDROYD

531.39

1080. Utilization of eccentrics for the mechanical realization of small displacements. R. SARDOS. *J. Phys. Radium*, **14**, 32 S–34 S (*Oct.*, 1953) *In French.*

Use is made of three interconnected disks to enable an object mounted on one disk to be subjected to small angular or linear displacements by relatively large rotations of one or more disks. Formulae for the sensitivity of the system are given and the problem of 4 interconnected disks is also briefly considered.

G. F. HODSMAN

MECHANICAL MEASUREMENTS 531.7

531.7

1081. A variable phase contact breaker for stroboscopic determination of waveform. V. R. PETERSON. *J. sci. Instrum.*, **30**, 457–8 (*Dec.*, 1953).

The contact breaker described enables rapid phase variation by known increments so that quantitative examination of periodically varying phenomena can be carried out. The positive action reversible escapement used is considered in detail. A.

531.717.1 : 532.65 : 778.3

1082. A photographic method of observing the approximate size of liquid droplets produced by an atomizer. R. A. BENTLEY, J. CARTWRIGHT AND R. L. GORDON. Note in *Brit. J. appl. Phys.*, **4**, 316 (*Oct.*, 1953).

Developer is sprayed on to a fogged plate, when the droplet pattern records itself by blackened spots.

S. T. HENDERSON

531.73 : 621.317.39

1083. Measurement of the size-distribution of spray particles. L. K. WHEELER. *Electronic Engng*, **25**, 402–6 (*Oct.*, 1953).

531.752 : 539.16

1084. Precision balances for radioisotopic applications. E. J. HATFIELD, JR. *Nucleonics*, **11**, 48–54 (*Sept.*, 1953).

Balances capable of weighing 5 kg, with a precision of 1 p.p.m. are described. The instruments are intended for weighing radioactive materials under remote operation. Movement of the balance beam is indicated at a control desk by means of a signal from an r.f. bridge circuit containing two capacitors, whose air gaps are varied by the movement. In each instrument the load pan is situated below the balance, inside a weighing hood, ventilation being so arranged that the air flows from the balance into the hood while weighing is in progress, to minimize the possibility of contamination. At all times other than during the actual weighing operation the balance is sealed from the weighing hood, and it can be easily separated from the latter for maintenance purposes. L. R. SHEPHERD

531.752 : 681.26

1085. Note on the principle of stabilization of an electronic thermobalance by means of magnetic damping. C. EYRAUD AND R. GOTON. Letter in *J. Phys. Radium*, **14**, 638 (*Nov.*, 1953) *In French.*

531.775 : 621.317.79

1086. An instrument for measuring speed fluctuations and a method of calibrating such instruments. A. SWINDELLS. *J. sci. Instrum.*, **30**, 364–5 (*Oct.*, 1953).

An a.c. tachogenerator followed by amplifier and filter equipment has been used to measure fluctuations in low rotational or linear speeds. The sensitivity is such that speed fluctuations in the frequency range of 10–60 c/s and amplitude 0·1 rev/sec can be measured directly or 0·03 rev/sec with an auxiliary amplifier. The load imposed on the measured system is low. A new method has been devised for the calibration of the instrument. A differential gear-box summates a steady speed and a sinusoidal oscillation, and the instrument is calibrated on the known output velocities of the differential. A.

531.787

1087. A capacitance manometer of low thermal sensitivity. I. G. BAXTER. *J. sci. Instrum.*, **30**, 456–7 (*Dec.*, 1953).

This has a volume elastic coefficient of 10×10^9 dyn/cm^5, and a basic temperature coefficient of about +250 p.p.m./°c. A compensating element can be fitted, for reducing the effect of temperature. A.

MECHANICS OF FLUIDS 532

532.133

1088. A new method of determining the internal viscosity of a chain macromolecule by measurements of flow birefringence. R. CERF. *C.R. Acad. Sci. [Paris]* **237**, 652–4 (*Oct.*, 1953) *In French.*

Describes in outline a theory involving dynamical and static anisotropies, to explain effects at high velocity gradients. This is confirmed by measurements on 4 polyisobutylenes. A simpler method of measuring internal viscosity will now be possible.

G. F. LOTHIAN

532.51

1089. Two-dimensional perturbation of linear [fluid] flow. E. HØILAND. *Geofys. Publ.*, **18**, *No.* 9, 12 *pp.* (1953).

Two-dimensional perturbations of the basic rectilinear flow of incompressible, homogeneous fluid between two parallel rigid surfaces, the axial velocity, u, along the x axis being a function of the perpendicular distance, z, from the lower rigid surface, thus $u = U(z)$, and the rigid walls being given by $z = 0$ and $z = h$. The vertical velocities, w, in the perturbed motion are given by $w'' = [u''/(U - c) + k^2]w$, where c is the velocity of propagation and k the wave number. This equation has a singularity for $u - c = 0$, except when $u'' = 0$ at the same place, i.e. except when an inflection point appears in the velocity profile, and the velocity of propagation is equal to the mean velocity at the point of inflection. An inflection point in the velocity profile is necessary if permanent waves (c real), without singularity in the added vorticities are to be possible. Permanent waves as the solution of the perturbation equation, when the velocity profile has a point of inflection, instability waves for the harmonic velocity profile, and general stability theorems are discussed. J. S. G. THOMAS

532.51

1090. On the dynamic effect of variation in density on two-dimensional perturbations of flow with constant shear. E. HØILAND. *Geofys. Publ.*, **18**, *No.* 10, 12 *pp.* (1953).

The basic flow considered is a rectilinear, horizontal current of incompressible fluid having a velocity, u, along the x-axis, given by the relation $u = az$, where z denotes the vertical coordinate; the fluid density, Q, is supposed to be given by the relation $Q = Q_0 \exp(-\beta z)$ where β is a constant. Positive values of β correspond to static stability, negative values to static instability. The kinematic effect of density variation is neglected, terms depending upon this variation being taken into account only when they occur along with g; the simplified system of equations may thus be applied quantitatively to fluid flow systems having a height h much less than $1/\beta$. The equation for the streamline function ψ (in the xz plane) for two-dimensional perturbation is $(\partial/\partial t + az\partial/\partial x)^2 \ (\partial^2\psi/\partial x^2 + \partial^2\psi/\partial z^2) = -\beta g \partial^2\psi/\partial x^2$. Assuming a wave-solution given by $\psi = Z(z) \exp[-ik(x + ct)]$, the amplitude function $Z(z)$ is given by $Z'' = [k^2 - \beta g/(az + c)^2]Z = 0$, where k is the wavenumber and c is the velocity of wave propagation in the negative x direction. The general solution for the amplitude function, Z, has been derived by Taylor in the form $Z = [z - (c/a]^{1/2} B_{\delta/2} ik[z - c/a]$, where $B_{\delta/2}$ is the cylindrical function of order $\delta/2$, with $\delta = [1 - 4\beta g/a^2]^{1/2}$. The case $k = 0$, i.e. for waves of infinite wavelength, is discussed. The solution for Z, in this case, assumes the form $Z = A(az + c)^{(1-\delta)/2}[(az + c)^\delta - B]$, where A and B are integration constants. J. S. G. THOMAS

532.51 : 530.145

1091. Variational principles in hydrodynamics. H. ITÔ. *Progr. theor. Phys.*, **9**, 117–31 (*Feb.*, 1953).

A canonical formalism in hydrodynamics is developed by aid of Clebsch's transformation. If the adiabatic process where the entropy is conserved is considered, vortex motion is found to be closely connected with the entropy. Euler's hydrodynamical equation emerges factorized into four fundamental equations which are discussed from the thermodynamical point of view. Many important relations in hydrodynamics are naturally introduced by these equations. Landau's theory of quantum hydrodynamics is criticized upon this theory. A.

532.51 : 533.6.011.31 : 778.3

1092. The use of schlieren methods in demonstration of fluid flow. F. SEIDL. *Acta phys. Austriaca*, **7**, *No.* 4, 417–19 (1953) *In German.*

A simple demonstration apparatus is described by means of which fluid flow patterns can be rendered visible. Sample patterns are shown. R. W. FISH

532.515 : 532.13 : 539.501

1093. Flow in visco-elastic fluids. J. E. CAFFYN. *Kolloid Z.*, **129**, 77 (1952) *In German.*

It is shown that the equations developed by Reiner and Rivlin and by Oldroyd lead to a parabolic velocity distribution. The velocity distribution was studied by photographing oildrops.

BRITISH SOCIETY OF RHEOLOGY

532.517.2

1094. Demonstration of parabolic velocity distribution in laminar flow. A. KOLIN. *Amer. J. Phys.*, **21**, 619–20 (*Nov.*, 1953).

Describes a method for rendering visible the parabolic velocity distribution in laminar flow through a conduit. An opaque cloud having the shape of a thin line disposed along a pipe diameter is created by electrochemical means. This line is distorted into a parabola by the motion of the fluid. A.

532.52.: 532.62

1095. Water bells. G. N. LANCE AND R. L. PERRY. *Proc. Phys. Soc.* [*London*] *B*, **66**, 1067–72 (*Dec.*, 1953).

Gives a theoretical study of the water bell phenomena, interest in which was revived by Hopwood [Abstr. 2459 (1952)]. A numerical method of solution of the differential equation of the bell's surface is described and the results obtained are given in the form of graphs. It is shown that the shapes depend on three parameters and, in order to determine numerical magnitudes of these, experiments similar to Hopwood's were performed. Photographs of the bells were obtained, four of which are included. The theoretical shapes are compared with those obtained experimentally showing the agreement between the two to be good. A.

532.526

1096. Growth of boundary layer on a rotating sphere. S. D. NIGAM AND K. S. I. RANGASAMI. *Z. angew. Math. Phys.*, **4**, *No.* 3, 221–3 (1953).

The initial motion of fluid, initially undisturbed, due to the sudden rotation of a sphere placed in the fluid, and which at time $t = 0$ is suddenly caused to rotate with spin Ω about a diameter is discussed mathematically. The boundary-layer equations are used to deduce the growth of the boundary layer, which originates at the pole and increases towards the equatorial section. Contrary to Howarth's results [Abstr. 3369 (1951)], the authors find an inflow of fluid to occur at the poles and an outflow at the equator. J. S. G. THOMAS

532.527 : 523.877

1097. The stability of rotating liquid masses. R. A. LYTTLETON. *Cambridge: University Press*, *vii* + 150 *pp.*

Review in *Phil. Mag.*, **44**, 1411 (*Dec.*, 1953).

532.583.3

1098. Short surface waves due to an oscillating immersed body. F. URSELL. *Proc. Roy. Soc. A*, **220**, 90–103 (*Oct.* 22, 1953).

A long circular cylinder of radius a, with its axis horizontal, is half-immersed in a fluid under gravity and is making periodic vertical oscillations of small constant amplitude and of period $2\pi/\sigma$ about this position. It is required to find the resulting fluid motion when the parameter $N = \sigma^2 a/g$ is large; the method of an earlier paper [Abstr. 4531 (1949)] is then unworkable. The present solution is made to depend on an integral equation which can be chosen to have a kernel tending to zero with N^{-1}, and which is solved by iteration. Successive terms in the iteration are of decreasing order, and the convergence of the method for sufficiently large N is proved. Expressions are given for the virtual-mass coefficient and for the wave amplitude at infinity. The

present work appears to be the first practical and rigorous solution of a short-wave problem when a solution in closed form is not available. It is suggested that a similar technique may be applicable to the diffraction problems of acoustics and optics, which have hitherto been treated by the approximate Kirchhoff–Huygens principle. A.

CAPILLARITY 532.6

532.61

1099. Interaction between surfaces in close proximity. L. F. Evans. Letter in *Nature* [*London*] **172,** 776–7 (*Oct.* 24, 1953).

When an air bubble is pressed against a plane glass surface under water, the disjoining water film may reach equilibrium thickness at which double layer repulsion is balanced by excess pressure of the bubble. The thickness is sensitive to the presence of surface-active impurities: for pure water and silica or glass surfaces the thickness is about 200 Å. Higher reported figures are almost certainly due to accidental contamination. R. F. BARROW

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

1100. On van der Waals' forces in liquids. Measurements of vapor pressures and calculating of vaporisation energy and London-forces in mixtures of nonpolar liquids. A. Niini. *Ann. Acad. Sci. Fennicae A I, No.* 121, 12 *pp.* (1953).

An empirical formula for the vaporization energy of pure nonpolar liquid is generalized to a corresponding formula with two alternative expressions for nonpolar binary mixtures of infinite dilution of the solute. The calculated values are compared with those computed as the difference between the internal vaporization heat of the pure solute and a correction term of the free energy and the entropy. The comparison makes a clear distinction between the two alternatives. Satisfactory values are given only by an equation in which the internal heat of vaporization and correspondingly the dispersion energy is inversely proportional to the 6th power of the mean distance of neighbouring molecules, but as well, proportional to the surface area (or $V^{2/3}$) of the solute molecules. A.

532.7

1101. Structure of liquid nitrogen, oxygen, and argon by neutron diffraction. D. G. Henshaw, D. G. Hurst and N. K. Pope. *Phys. Rev.*, **92,** 1229–34 (*Dec.* 1, 1953).

The structures of liquid oxygen, nitrogen, and argon have been investigated by measuring the scattering of neutrons of wavelength 1·08 Å over the angular range 4° to 78°. The scattering curves have been transformed to give the time average of the atomic density as a function of the distance from an atom taken as centre. The deviation from the mean density is an oscillating function with an amplitude which decreases more rapidly than the inverse square of the distance from the central atom. In nitrogen a single neighbour is found at a spacing of 1·1 Å from each atom, corresponding to a diatomic molecule in the liquid. In oxygen 1·5 neighbours are found at approximately 1·25 Å from each atom, suggesting that the degree of association is greater than diatomic. The results are not inconsistent with the suggested existence of the O_4 molecule. In argon the results are in reasonable agreement with published X-ray determinations. A.

532.7 : 533.7

1102. A quasi-lattice theory of real gases and of strong electrolytes in solutions. M. Dutta. *Proc. Nat. Inst. Sci. India,* **19,** 183–94 (*March–April,* 1953).

The theory is similar to the theory of solids developed by Frenkel and others, and to that of liquid by Lennard-Jones and Devonshire. The systems of real gases and ions of strong electrolytes in solutions are taken as sorts of alloys of the molecules (atoms or ions) and the holes. From this picture and by the method of Planck and Lorentz based on Boltzmann's principle, expressions for usual thermodynamic functions and laws of microscopic distributions have been deduced. A.

532.73

1103. Theoretical interpretation of the cryoscopic curves of solutions in strong electrolytes. Attempt at generalization. G. Petit. Letter in *J. Phys. Radium,* **14,** 548–9 (*Oct.*, 1953) *In French.*

As in the expression for the osmotic effect there appear two parameters, the activity, and the factor taking account of the particle nature of the solute, interpretation is possible only for infinitely dilute solutions. Experimental data show that very, though not infinitely, dilute solutions behave practically as ideal solutions, which indicates that the interaction between the dissolved particles is indistinguishable from that with the solvent. In such a solvent the only corrective parameter is the activity factor. The cryoscopic curves intersect, except at high dilution, where they are horizontal. The latter fact indicates that Raoul's law holds rigorously, but a sloping curve indicates a change in the orientation of the particles or a formation of weak bonds between solute and solvent. In general, binary oxides cause less sloping curves for metals with more positive character, and alkali fluorides yield horizontal curves. A. J. TAYLOR

532.73–3 : 548.58

1104. The mechanism of dissolution of salt crystals. R. Bloch and M. Reiner. *Bull. Res. Coun. Israel,* **2,** 263–5 (*Dec.*, 1952).

The role played by a film of saturated solution in protecting the non-horizontal surfaces of the crystal from dissolution is discussed. The film consists of a number of vortices which cause it to "stick" to the solid. Growth of crystals may also involve the same effect which is not a manifestation of surface tension or of ordinary diffusion. S. J. GREGG

532.739.2 : 535.343.32–32

1105. Solubility studies by means of ultraviolet light absorption. M. L. Marshall and E. L. King. *Texas J. Sci.*, **5,** 380–90 (*Sept.*, 1953).

The method is illustrated by the systems, naphthol in hexane, and by an aldehyde, three ketones, two aromatic hydrocarbons and a pyrimidine derivative in water. A.

MECHANICS OF GASES 533

533.6

1106. A method of solution of the equations of classical gas-dynamics using Einstein's equations. G. C. McVittie. *Quart. appl. Math.*, **11**, 327–36 (*Oct.*, 1953).

It is known that Einstein's equations in general relativity provide explicit expressions for the density, pressure and velocity of a perfect gas in terms of the coefficients of the metric (the potentials) and hence in terms of the coordinates. Using orthogonal space-times, the expressions involve four potentials only between which consistency relations hold. It is shown how degeneration of the Einstein equations to Newtonian hydrodynamics provides general solutions of the equations of classical gas-dynamics for motions which may be either of constant or of variable entropy. The consistency relations are obtained in the general case. As an illustration, one-dimensional gas-dynamics are discussed and it is shown how the consistency relations are manipulated. The solution in which one or other of the Riemann variables is constant is obtained as a special case and motions of variable entropy are also attained. A.

533.6

1107. Spherically symmetric solutions of the equations of gas dynamics. G. C. McVittie. *Proc. Roy. Soc. A*, **220**, 339–55 (*Dec.* 8, 1953).

The method developed in the previous abstract is adapted to the case of spherically symmetric gas motions. The pressure, density and velocity of the gas are shown to involve one arbitrary function ϕ; if $\phi = f(t)\ w(rt^{-\alpha})$, where f and w are arbitrary functions, explicit formulae for the pressure, density and velocity are worked out. Amongst motions of this kind, those in which the velocity is proportional to r, are selected for detailed investigation. Cases in which the gas motion is adiabatic are determined; in one type w is a known function of $rt^{-\alpha}$, while f is the solution of a certain differential equation; in a second type, f is known but w remains arbitrary. Boundary conditions are then applied, first, on the assumption that the boundary is approximately a contact surface and that the motion is of the first type; secondly, when the boundary is a true shock surface and the motion has a special character and is common to both types. Primakoff's solution is obtained in the second case. The author's method is contrasted with the conventional ones. A.

533.6.01

1108. Transonic flow past a wedge at zero angle of attack. L. Trilling. *Z. angew. Math. Phys.*, **4**, *No.* 5, 358–75 (1953).

The steady plane flow of an inviscid ideal gas past a thin symmetric diamond wedge at zero angle of attack at speeds just below that of sound is discussed mathematically. A solution of the transonic equation, approximately satisfying all the boundary conditions, is built up in the hodograph plane from an appropriate singular solution, a stagnation solution and a series of regular solutions. A rather complete picture of the flow field is derived from this solution including the variation of size and shape of the supersonic region, and the position and strength of the shock wave bounding it on the downstream side. The pressure drag agrees well with that deduced in Cole's theory, and with Bryson's measurements for the front of the wedge, and agrees fairly with Vincenti's curve for the range $\xi_0 = M = 1$. J. S. G. Thomas

533.6.011

1109. On the stability of Bénard–Kármán vortex street in compressible fluids. I. M. Z. v. Krzywoblocki. *Acta phys. Austriaca*, **7**, No. 3, 283–98 (1953).

General expressions are found for the velocity components due to a system of rectilinear vortices in a compressible fluid occupying an infinite two-dimensional space. Taking the von Kármán criterion of stability as the basis of the analysis, it is shown that (i) a single infinite row of equidistant vortices all having the same strength and velocity divergence, (ii) the two classical forms of the Bénard–Kármán vortex streets are all unstable. The role of compressibility in these stability phenomena is a negative one. It is pointed out that von Kármán's criterion does not always provide a suitable definition of stability, and that other proposed criteria should be investigated with reference to the compressible flow régime. A. T. Price

533.6.011.31 : 778.3 : 532.51

The use of schlieren methods in demonstration of fluid flow. *See Abstr.* 1092

533.6.011.312

1110. Boundary layer growth on a spinning body. C. R. Illingworth. *Phil. Mag.*, **45**, 1–8 (*Jan.*, 1954).

The skin frictional force is calculated for a body of revolution in the early stages of a suddenly initiated (and subsequently constant) screw motion about the axis of symmetry. In particular the effect of spin on the time of separation of the boundary layer of a sphere in such a motion is determined. A.

533.6.011.4

1111. Integration of the equations of transonic flow in two dimensions. D. Meksyn. *Proc. Roy. Soc. A*, **220**, 239–54 (*Nov.* 10, 1953).

The equation for the velocity potential ϕ of compressible flow is transformed to α, β co-ordinates, where $\alpha + i\beta$ is the corresponding complex potential of the incompressible flow; the equation is then integrated on the following assumptions: (1) Compressibility in the case of subsonic and transonic flows can be considered as a perturbation effect, and the equation for the velocity potential ϕ can be treated as a form of the non-linear Poisson equation. (2) To a first approximation $\partial\phi/\partial\beta$ is disregarded; $\partial\phi/\partial\alpha$, which only appears in the equation multiplied by a rapidly varying function, is taken to be constant in differentiation and integration; $\delta^2\phi/\delta\alpha^2$ and $\partial^2\phi/\partial\beta^2$ are, however, retained in the equation. The integration leads to an algebraic equation of fifth degree in the unknown quantity $\partial\phi/\partial\alpha$, which can thus be evaluated at any given point of the fluid. The condition for the occurrence of double roots in this equation determines the characteristic Mach number at which, it is assumed, a shock wave first appears. The method is applied to the motion past a circular cylinder, and the results are compared with Imai's solution based on Janzen–Rayleigh's method, and with Woods's calculations by the relaxation

method. The agreement is satisfactory in both cases. The Mach number first reaches its characteristic value due to conditions at the point $\theta = \frac{1}{2}\pi$, $r = 1$, and is equal to $M_1 = 0{\cdot}414$; the characteristic velocity is $q = 2{\cdot}75$ (corresponding to $q = 2$ for incompressible flow) and the characteristic local Mach number is $M_e = 1{\cdot}29$. The method is also applied to an aerofoil of thickness $\frac{1}{10}$, which consists of two arcs with cusps at leading and trailing edges; and when the results are compared with Kaplan's calculations, the agreement is close. The characteristic Mach number is $M_1 = 0{\cdot}839$, the increase in the velocity over that of incompressible flow is 32% and the local characteristic Mach number is $M_e = 1{\cdot}44$. A.

533.6.011.4

1112. Pressure fluctuations in a jet engine. H. M. Nicholson and A. Radcliffe. *Brit. J. appl. Phys.*, **4**, 359–65 (*Dec.*, 1953).

Pressure fluctuations have been recorded at various points in the ducting of a jet engine. The recordings were made under a variety of steady running and accelerating conditions with a standard engine and with engines adapted for two different after-burning systems. This report includes a brief description of the recording equipment and its method of use, a summary of the test conditions, a description and analysis of the pressure records obtained and a discussion of the test results. In the discussion an attempt is made to explain the observed pressure fluctuations, and their significance in relation to practical engine operation and combustion system design is stressed. A.

533.6.011.5

1113. Interferometric studies of supersonic flows about truncated cones. J. H. Giese and V. E. Bergdolt. *J. appl. Phys.*, **24**, 1389–96 (*Nov.*, 1953).

Fringe shifts on interferograms of flows at $M = 2{\cdot}45$ about variously truncated 15° (half-angle) cone cylinders in free flight in a pressurized range have been examined for similarity of the flow fields, occurrence of scale effects, and convergence to conical flow. It was found that flows over similar objects with equal tip Reynolds numbers were similar and that convergence to conical flow occurred before the disturbance at the tip had been reflected the second time along characteristics to the body. Density distributions have been determined, and a number of comparisons have been made with theoretical predictions. A.

533.6.011.5

1114. On the mechanism of choked jet noise. A. Powell. *Proc. Phys. Soc.* [*London*] *B*, **66**, 1039–56 (*Dec.*, 1953).

The character of jet noise undergoes a marked change above choking, the noise due to turbulent mixing being dominated by a powerful whistle or screech whose wavelength is related to the regular shock wave spacing. The mechanism in two-dimensional flow is further examined (by the aid of a dynamic Schlieren apparatus), verifying the suggested mechanism and showing the similarity to that in axially symmetric flow where discontinuities in frequency, partly analogous to edge tones, occur. The resultant sound emitted as the periodic eddy system traverses the regular shock-wave pattern is highly directional, producing a powerful beam at doubled frequency normal to the jet and an intense beam at eddy frequency in the upstream direction adjacent to the jet, resulting in fluctuations in jet velocity direction at the orifice which initiate new stream disturbances. A gain criterion for the self-maintained cycle is given, enabling certain qualitative deductions concerning the intensity to be made, and use will be made of this in considering methods of reducing the noise level. A.

533.6.08

1115. Pressure response in supersonic wind-tunnel pressure instrumentation. A. L. Ducoffe. *J. appl. Phys.*, **24**, 1343–54 (*Nov.*, 1953).

In the development of high-speed aircraft, rockets, missiles, etc., wind tunnel pressure measurements at supersonic velocities are necessary to determine certain aerodynamic characteristics. Because of the lack of knowledge concerning the proper choice of parameters in the design of pressure instrumentation, the response time has been known to exceed the running time in the case of the intermittent tunnel. Pressure systems consisting of an orifice, a capillary tube, a length of connecting tubing and a pressure-sensitive element connected in series are analysed. The time required for the pressure in the pressure-sensitive element to reach within 1% of the equilibrium pressure is defined as the response time of the system. Experiments were conducted to determine the effect of the various geometric and dynamic parameters on the response time. Analytical solutions of the flow equations by numerical integration are carried out for the special case of a length of capillary tubing connected to the pressure-sensitive element for three different inside diameters. The data indicate that the response time can be maintained within acceptable limits for present-day supersonic wind tunnel installations by proper choice of the geometric and dynamic parameters. A.

533.6.08

1116. An automatic micromanometer for the measurement of low air speeds. R. A. K. Long. *J. sci. Instrum.*, **30**, 481–2 (*Dec.*, 1953).

A two-liquid, null-reading micromanometer, which is electrically driven to the balance point under the control of an electronic proximity switch, is described. Readings of pressure at a Pitot head are repeated up to seven times a minute with an accuracy of $\pm 0{\cdot}00005$ in. of water head, assuming the electronic instrument is stable. A.

MOLECULAR THEORY OF GASES 533.7

533.7

1117. The imperfect gas. T. H. Berlin, L. Witten and H. A. Gersch. *Phys. Rev.*, **92**, 189–201 (*Oct.* 1, 1953).

The partition function of the classical imperfect gas is approximated by means of a generalized cell model in which the number of particles in a cell is taken as the statistical variable. The limiting free energy per

particle exhibits critical phenomena, and, for temperatures less than the critical temperature, the p-v isotherm is a nonanalytic function of v consisting of three pieces. These properties depend only on the interparticle potential energy having the general features usually assigned to it. However, the condensation pressure is not constant, and, for temperatures sufficiently low, the isotherm shows thermodynamic instability. The model allows the calculation of the limiting free energy per particle for all values of the temperature and specific volume. A.

533.7 : 532.7

A quasi-lattice theory of real gases and of strong electrolytes in solutions. *See Abstr.* 1102

533.7 : 536.7 : 530.162

Lectures on theoretical physics. Volume 5. Thermodynamics and statistics. *See Abstr.* 1077

VIBRATIONS . ACOUSTICS 534

534.014.5

1118. Hereditary dynamical systems with "déferlement." T. Vogel. *Ann. Télécomm.*, **8**, 354–60 (*Nov.*, 1953) *In French.*

The existing literature on nonlinear dynamical oscillations is briefly reviewed. Then a new category of dynamical systems is defined. Periodic solutions and their stability are discussed, and some of the results obtained have been verified by experiment. It is shown how these systems may be incorporated into the hereditary systems of Volterra. L. S. GODDARD

534.114 : 621.372.412

1119. An electrostatically maintained tuning fork. E. G. Richardson and Y. L. Yousef. *Proc. Univ. Durham Phil. Soc.*, **11**, *No.* 9, 119–24 (1953).

A very simple quartz crystal oscillator circuit is used to maintain and pick up the vibrations of a tuning fork or a metal rod with a low fundamental frequency. The driving action appears to depend on a regenerative modulation of the h.f. voltage on the condenser plates of the tuned circuit, the vibrating system forming a part of the capacitance. A tuning fork with a natural frequency of 25 c/s could be steadily maintained to give a sinusoidal output of 10 V on a 2000 Ω load in a single triode circuit. The arrangement is suggested as a l.f. generator with the desirable features of high stability of frequency combined with remarkable tone purity. A.

534.13

1120. On the theory of free oscillations of isotropic elastic media. E. Ledinegg and P. Urban. *Acta phys. Austriaca*, **7**, *No.* 4, 420–35 (1953) *In German.*

Small perturbation calculation of the first order is used to find the variations in vibration frequency of a three-dimensional body caused by small changes in density and elastic parameters of the medium and small boundary deformations. As examples are considered the cases of stratified media, such as a cylindrical resonator filled with a fluid into which a rod is inserted along its axis, or a plate parallel to its bottom. A. GELBTUCH

534.2 : 530.145

1121. The quantization of sound waves. I. General theory. O. Penrose. *Phil. Mag.*, **45**, 80–92 (*Jan.*, 1954).

The theory described was developed with a view to its application to the molecular theory of helium II. This application will be discussed in a subsequent paper. The system treated consists of a very large number of identical interacting particles. Sound waves can be described using the Fourier components of the density operator and their time-derivatives. Approximate commutation relations for these operators are obtained, and equations of motion are deduced from the assumption that the system can propagate sound. The commutation relations are analogous to those for a set of harmonic oscillators or for a radiation field; using this analogy, creation operators, which can be said to create phonons, are defined. It is shown how stationary states may be constructed by adding phonons to the ground state, and that the energy or momentum of such a stationary state equals the energy or momentum of the ground state plus that of the "phonon gas" added to it. The theory is illustrated by its application to three particular cases—the imperfect Bose gas, linear imperfect Fermi gas, and linear crystal. In each case the present general method leads to approximately the same creation operators as the special treatments due to other authors. A.

534.222.2

1122. A note on shock propagation in brass. J. Savitt. Letter in *J. appl. Phys.*, **24**, 1335 (*Oct.*, 1953).

The results of Shreffler and Deal [Abstr. 2749 (1953)] on the initial free surface velocities in naval brass plates originating from a contact explosion show a marked discontinuity if the reciprocal of the velocity, $1/v$, is plotted against the plate thickness, τ. $1/v$ is a linear function of τ, but when $\tau = \frac{1}{4}$ in., the slope changes to 1/10th of its original value. No explanation is offered. H. J. H. STARKS

534.222.2

1123. Observation of shock formation and growth. A. B. Laponsky and R. J. Emrich. *J. appl. Phys.*, **24**, 1383–8 (*Nov.*, 1953).

Transient one-dimensional flows have been produced by accelerating a piston in a gas-filled tube. Accelerations of the order of $2{\cdot}5 \times 10^4$ m/sec^2 produced shocks within 5 m of the initial piston position. The piston was propelled pneumatically. Shocks formed at the head and in the interior of the compression waves. By optically detecting the piston and shock positions and recording the corresponding times on a rotating drum chronograph with microsecond accuracy the properties of the compression wave and resulting shock were determined. The formation and growth of shocks were calculated from the compression wave measurements using the method of characteristics and the assumptions employed by Chandrasekhar and Friedrichs. The observed and calculated shock properties were in reasonably good numerical agreement. Consistent lagging of the observed behind the calculated shock positions (order of 0·05 m at 5 m from initial piston position) is

attributed to the interaction of the flow with the tube walls. A.

534.222.2

1124. Parameters characterizing the strength of a shockwave. R. N. HOLLYER AND O. LAPORTE. *Amer. J. Phys.*, **21**, 610–13 (*Nov.*, 1953).

Inspection of the equations of compressible hydrodynamics in one dimension shows that the steady state may possess a discontinuity in the flow variables u, p, ρ. From this there arises the possibility of constructing a dimensionless parameter characterizing shock strengths. Its relations with other shock parameters are discussed. A.

534.23

1125. Study of the absorption of ultrasonic waves of 5 Mc/s in organic liquids by the radiation pressure method. S. PARTHASARATHY, S. S. CHARI AND D. SRINIVASAN. *J. Phys. Radium*, **14**, 541–6 (*Oct.*, 1953) *In French.*

The authors employ the radiation pressure method with slight modification and discuss the errors and precautions necessary. They show that liquids can be classified into four groups, according to their structure, in each of which the ratio $\alpha_{obs.}/\alpha_{calc.}$ has a representative value. T. C. TOYE

534.232

1126. The underwater spark as a source of sound impulses. H. DRUBBA AND H. H. RUST. *Arch. elekt. Übertragung*, **7**, 429–40 (*Sept.*, 1953) *In German.*

Account of investigations into behaviour of sparks, produced by discharging a condenser charged to voltages between 0·5 kV and 5 kV, across an underwater spark-gap with a length of 0·1 or 0·3 mm. Results given include photographs, curves of current against time and information about propagation of sound waves through the water. Bibliography contains 138 references. V. G. WELSBY

534.321.9 : 535.42

Diffraction of light by ultrasonic waves. *See Abstr.* 1212–13

534.39

1127. Acoustic radiation pressure of plane compressional waves. F. E. BORGNIS. *Rev. mod. Phys.*, **25**, 653–64 (*July*, 1953).

Both electromagnetic and acoustic waves exert forces of radiation upon an obstacle placed in the path of the wave, the forces being proportional to the mean energy density of the wave motion. In electromagnetics the action of these forces is relatively easily understood through the concept of Maxwell's electromagnetic stress tensor. The physical processes leading to these forces in a sound wave have been found to be considerably more complex; the difficulties belong to the fact that the acoustic wave equation is not linear and that a beam of finite cross-section is subject to effects caused by the surrounding medium. Though many papers have been devoted to the subject and though various theoretical approaches have been made, some difficulties still seem to stand in the way of a clear understanding of the physics of the problem. The purpose of the present study is especially to throw light on the physical aspects. The approach adopted, which uses the momentum theorem, is believed to serve this purpose especially well. The expression for the radiation pressure is given in both Eulerian and Lagrangian co-ordinate systems. Special consideration is given to liquids of constant compressibility, since in such media the processes involved can be dealt with mathematically in a simple manner. The general case of a plane reflector with arbitrary reflection coefficient is treated; the *modus operandi* of the forces at the interface between liquid and obstacle is explained for some special cases, including the radiation forces on the interface between two non-miscible liquids. Finally, a general relation is established between the energy density and the pressure caused by radiation falling normally upon a plane reflector, which, under certain assumptions, is valid in any fluid and at any amplitude. A.

534.39 : 542.952.7

Depolymerizing effect of ultrasonic cavitation of vapour in a solution in an electric field. *See Abstr.* 1831

OPTICS . RADIATION . SPECTRA 535

535.11 : 537.533.9

Visible light from localized surface charges moving across a grating. *See Abstr.* 1397

535.215 : 522.615

Investigation of a photoelectric photometer, attached to the 100 cm Schaertelescope. *See Abstr.* 982

535.215.2 : 537.564 : 535.343.4–32

Photo-electric yields of Pt and Ta in the vacuum ultraviolet. *See Abstr.* 1185

535.23.08

1128. Filter radiometry and some of its applications. R. STAIR. *J. Opt. Soc. Amer.*, **43**, 971–4 (*Nov.*, 1953).

Filter radiometry is discussed in terms of its general application to the study of various problems involving the accurate measurement of radiant energy or the calibration of selective radiant energy detectors. As an example of its use data are given on the method and results of total ozone measurements at Sacramento Peak, New Mexico, in June, 1949. A.

535.233

1129. The value of the constant in Wien's displacement law. A. H. BOERDIJK. *Philips Res. Rep.*, **8**, 291–303 (*Aug.*, 1953).

It is shown that the current definition of monochromatic intensity (I_λ) contains an arbitrary element. Other definitions are considered, based on a logarithmic wavelength scale (I_r) or on a frequency scale (I_ν). For the black-body radiation the maxima of these intensities occur at different places in the spectrum, giving rise to three different constants in Wien's law. The question arises which one should be used. It appears that the use of the value 0·2896 cm °K is a matter of convention only. There are logical arguments for replacing the above constant by the value 0·3668 cm. °K. A.

535.241 : 628.9

1130. Basic quantities and concepts used in illuminating engineering. D. M. FINCH. *Illum. Engng*, **48**, 375–82 (*July*, 1953).

A treatment from first principles of the basic photometric quantities and their definitions. The symbol L is used for luminous emittance (lumens emitted per unit area of a surface) and B for "photometric brightness." International agreements are ignored. The footlambert and similar units are described as measures of uniform, average or equivalent photometric brightness. J. W. T. WALSH (R)

535.247.1

1131. A new sensitive chemical actinometer. I. Some trials with potassium ferrioxalate. C. A. PARKER. *Proc. Roy. Soc. A*, **220**, 104–16 (*Oct.* 22, 1953).

A chemical actinometer has been devised whose high sensitivity and precision depends upon the spectrophotometric determination of the photolysis products of potassium ferrioxalate with 1 : 10 phenanthroline. The sensitivity is some hundreds of times greater than that of the uranyl oxalate actinometer. The behaviour of the actinometer has been investigated in detail at 3650 to 3663 Å, and tests also show that it is suitable for use over a wide range of wavelengths. The approximate quantum efficiency has been determined at twelve wavelengths between 4900 and 2537 Å. The advantages and possible applications of the actinometer in the measurement of small doses of radiation are discussed. A.

535.31

1132. Some generalizations in geometrical optics derived by a convergence method. E. J. IRONS. *Amer. J. Phys.*, **21**, 590–602 (*Nov.*, 1953)

A simple but general treatment of reflection and refraction at spherical surfaces is based on properties of nodal points and the specification of wave fronts by their convergences. Rules for the location and description of images are justified and extended to the images formed by thin lenses, the positions of whose nodel points make apparent an analogy with single refracting surfaces. The formula for the change in convergence of a wave front proceeding in a homogeneous and isotropic medium is applied to describe the images of axial objects, to derive Newton's relation in generalized form and to consider refraction by separated refracting surfaces of unspecified powers. Solutions to five numerical problems, obtained by methods advocated in the paper, are appended. A.

535.31 : 535.13

1133. The derivation of geometrical optics from Maxwell's field theory. G. MANDL. *Acta phys. Austriaca*, **7**, *No.* 4, 365–89 (1953) *In German.*

The "eikonal" equation for an anisotropic, inhomogeneous medium is derived from the wave equation and related to Fermat's principle, from which all geometrical optics can be derived. The domain of validity of geometrical optics is examined.

P. T. MATTHEWS

535.31 : 535.833

1134. Considerations on the Schmidt telescope. C. MORAIS. *An. Real. Soc. Espan. Fis. Quim.*, **48(A)**, 153–70 (*May–June*, 1952) *In Spanish.*

The equation corresponding to the deformed surface of the Schmidt plate is found, which causes the spherical aberration to be completely corrected for all the apertures of the "mirror-plate" optical system. The position of the plate is determined which is necessary in order to obtain the correction of the sine aberration. The longitudinal chromatism is considered, limiting the study to the chromatic difference of the spherical aberration of the third order. The oblique aberrations of higher order, which by their presence limit the useful field of the "mirror-plate" optical system—a well-known fact—are not discussed. A.

535.317

1135. Achromatic condition for a combination of two lenses kept at a distance. M. S. SODHA AND A. N. NIGAM. Letter in *Curr. Sci.*, **22**, 232–3 (*Aug.*, 1953).

An equation for the power of two thin separated lenses is differentiated with respect to wavelength and values of the glass constants from the Hartmann dispersion formula are substituted. The conditions for achromatism and the power of the system are then deduced. R. W. FISH

535.317 : 771.372

1136. Design for an auto-focus range finder. H. ASHER. *J. sci. Instrum.*, **30**, 402–3 (*Nov.*, 1953).

In Abstr. 1485 (1953) it was shown that a camera range finder may be designed so that the movement of one of the lenses of a sliding lens compensator may be made equal to the movement of the camera lens required for focusing. The practical application was prevented by the condition that the range finder should be situated at the anterior focal point of the camera lens. Here a modified design is described which overcomes this difficulty. A.

535.317.1

1137. The estimation of image perfection by definition brightness or $\lambda/4$ criterion. H. SLEVOGT. *Optica Acta*, **1**, 21–4 (*Jan.*, 1954) *In German.*

A new representation of the wave aberration supplies the *definition* as square of the chord of a curve of given length. A complete survey of all types of wave-surfaces with given definition is obtained by this way. The examples of a phase-plate and a bifocal lens demonstrate that the fulfilment of the $\lambda/4$ rule of Rayleigh is neither necessary nor sufficient to obtain the desired definition of 80%. A.

535.317.25

1138. A method of improving the resolving power of optical instruments. P. LACOMME. *Optica Acta*, **1**, 33–8 (*Jan.*, 1954) *In French.*

A stigmatic objective separates two stars when the variation of phase difference of vibrations arriving at the extreme edges of the pupil is sufficient, on passing from one star to the other. It is possible artificially to increase this phase difference by absorbing, by means of an opaque screen, part of the image, which is then reimaged by a second system. The distribution of amplitude and phase in the final image is thus modified: two stars appear more separated than geometrical optics would indicate. The procedure can be applied to improving the resolving power of astronomical telescopes and of spectrographs. A.

535.317.25 : 535.42

1139. An experimental study of the limit of resolution of two points of light as a function of their coherence. A. ARNULF, O. DUPUY AND F. FLAMANT. *Nuovo Cimento*, **9**, *Suppl. No.* 3, 225–30 (1952) *In French.*

Experiment is in general agreement with the theory of Hopkins [Abstr. 7782 (1951)] and shows resolution improved up to 10 times over the incoherent case, when the sources are π out of phase. D. H. WHIFFEN

535.317.5

1140. On the image sharpness in the central field of a system presenting third- and fifth-order spherical aberration. G. TORALDO DI FRANCIA. *J. Opt. Soc. Amer.*, **43**, 827–35 (*Oct.*, 1953).

It is customary in photographic lenses to leave some third-order spherical aberration to partially compensate the higher order terms. However, so far no satisfactory answer has been given to the question of the amount of third-order aberration which gives the best balance. The problem has been attacked with the assumption that all the higher order terms can be approximately included in the fifth-order term, a situation that in most practical cases holds with great accuracy. It has also been assumed that useful indications regarding the image sharpness resulting from a given correction can be arrived at by pure geometrical optics. The illumination in the image of a sharp edge has been calculated for a constant fifth-order aberration and for different values of the third-order aberration and of the distance of the image plane from the paraxial focus. The numerical integration needed has been carried out with the aid of an IBM computing machine. The best results are obtained for a condition approaching that of the smallest circle of confusion. A.

535.317.6

1141. Classification of the geometrical aberrations of optical systems without symmetry of revolution. M. MONTEL. *Rev. Opt.*, **32**, 585–600 (*Nov.*, 1953) *In French.*

The aberrations are first classified and the variations of these aberrations with the position of the aperture diaphragm are studied. It is then shown how this general case leads to the case of systems with symmetrical parts, and this theory has been applied to excentric aberrations of centred systems. A.

535.317.6

1142. On the light distribution in the image of a line element for aberration functions of second order in the pupil variables. R. KRIEGER. *Optica Acta*, **1**, 9–20 (*Jan.*, 1954) *In German.*

A method of calculation of the light intensity in the image of a meridional or sagittal line element is given which is valid for aberration functions of any degree in the pupil variables. The method is used in this paper only for aberration functions of second degree in the pupil variables; the light distribution can then be expressed by simple functions. Typical curves of light distribution are given. A.

535.317.8

1143. Paraxial and third order data of corrected doublets. A. C. S. VAN HEEL. *Optica Acta*, **1**, 39–49 (*Jan.*, 1954).

A compilation in a comprehensive form of data of corrected doublets is given as an extension of those of Smith and Milne (1920). Some useful paraxial values have been included and the information of third-order aberration is amplified, together with formulae and values for other magnifications of object and stop. In view of the application of these data the formulae for the composition of two systems are also given. A.

535.323 : 539.234

1144. On a new method allowing the determination of the index and the thickness of a thin transparent film. F. ABELÈS. *C.R. Acad. Sci.* [*Paris*] **237**, 883–4 (*Oct.* 19, 1953) *In French.*

See Abstr. 6596 (1953). It is now shown that the index can be derived by means of an equation of the second degree. The method has been applied to thin films of titanium oxide, using green mercury light. The errors in the method are discussed. S. TOLANSKY

535.33 : 537.523.4

Absorption investigations in controlled spark discharges. *See Abstr.* 1351

535.33.07

1145. The application of a system of graduated diaphragms to Littrow's spectrograph (with glass optical system). II. E. MARQUÍNEZ AND A. CAMUÑAS. *An. Real. Soc. Españ. Fis. Quim.*, **48(A)**, 175–86 (*May–June*, 1952) *In Spanish.*

For Pt I, see Abstr. 8774 (1952). By applying a system of rectangular diaphragms with constant bases, and with openings of 2–4–6–8–12–16–24–32 mm to the flint-glass Littrow spectrograph, a gradual decreasing of the intensities of the spectral lines is obtained, the ratios of which correspond to those of the diaphragms. The diaphragms are placed on the mounting of the collimator, and in front of the prism, that is at the optical part of the spectrograph, where the light beams are parallel. In this way the characteristic curves of the photographic emulsions are obtained and can therefore be applied immediately to quantitative analysis. A.

535.33.07 : 537.523.4

1146. Spectrograph for the time study of sparks. F. RIMBERT. Letter in *J. Phys. Radium*, **14**, 638–40 (*Nov.*, 1953) *In French.*

A rotating mirror in front of the photographic film draws out the spectrum at right angles to the wavelength scale, so that a height of 1 mm $\simeq$ 4·6 μsec. G. F. LOTHIAN

535.33.07 : 535.339

1147. Method of focalization of a monochromator for the far ultraviolet with fixed, separated slits. S. ROBIN. Letter in *J. Phys. Radium*, **14**, 551–2 (*Oct.*, 1953) *In French.*

The geometry and linkage system for a new grating monochromator are given and a numerical example quoted. Advantages of the system are briefly described. R. W. FISH

535.33.07–14

1148. A microwave spectroscope for the 1·25 cm wave region. J. C. VAN DEN BOSCH AND F. BRUIN. *Nuovo Cimento.* **9**, *Suppl. No.* 3, 238–44 (1952).

A description of the spectroscope in use at the Zeeman laboratories, Amsterdam, and its performance. D. H. WHIFFEN

535.33.07–15

1149. Infrared recording of optical density *vs* linear frequency. J. H. DANIEL AND F. S. BRACKETT. *J. Opt. Soc. Amer.*, **43**, 960–8 (*Nov.*, 1953).

The rapidly augmenting library of known molecular spectra makes standardized choice of scales urgent. Conversion of an early single beam instrument to double beam, recording optical density, transmission or single beam v linear frequency, is described. An amplifier based upon the time sharing (Hornig) principle provides servo control of slit, gain, time constant and recording rate to reduce the noise at high densities and provide adequate speed of recording. A.

535.338–31

1150. Structure of the spectrum of Re I. R. VELASCO. *An. Real. Soc. Espan. Fis. Quim.*, **48**(A), 55–72 (*March–April*, 1952) *In Spanish.*

Gives measurements in the arc spectrum of Re in the region 2·000–1·500 Å. The analysis of the spectrum of neutral rhenium is reviewed. One even, and 28 odd news levels, have been found. Tables of the new energy levels and the new classified lines are given. The lowest odd terms belonging to the configuration $5d^56p$, and some other even and odd terms, have been fixed. A.

535.338.3

1151. The spectrum of singly-ionized carbon, C II. S. GLAD. *Ark. Fys.*, **7**, *Paper* 2, 7–32 (1953).

This was studied in the region 8800–1987 Å by means of a condensed hollow cathode discharge. About 60 new energy levels have been determined. From several intercombination lines observed an exact linking up of the doublet and quartet systems has been obtained. The distance between the two limits $2s\,^1S_0$ and $2p\,^3P_2$ has been established to be $52\,423 \pm 7\ \mathrm{cm}^{-1}$. A.

535.338.3

1152. Determination of the relative intensities in the triplet $4d^3D - 4p^3P^0$ in Zn I spectrum. M. D. KUNISZ. *Bull. Acad. Polon. Sci. Cl.* **3**, **1**, *No.* 1–2, 52–4 (1953).

The intensities J_λ are in the ratio $J_{3345} : J_{3303} : J_{3382} = 100 : (60 \pm 1) : (22 \pm 2)$ and agree with the summation rule. Experimental details are given for correcting for a non-uniform continuous background spectrum from the arc. A. G. GAYDON

535.338.3

1153. Interference measurements in the spectrum of argon I. K. BURNS AND K. B. ADAMS. *J. Opt. Soc. Amer.*, **43**, 1020–4 (*Nov.*, 1953).

The region 9657–5450 Å was observed with the type of source described by Meggers and Westfall, Hg^{198} with argon as carrier gas excited by high-frequency oscillation. Fifty argon lines were compared with 5460·7532 Å of Hg^{198}. Nineteen of these were well observed both by the present authors (AOW) and by Meggers and Humphreys (MH). The mean difference (AOW) − (MH) is +0·0003 Å, the median difference is ±0·0003 Å. In the course of observing the spectrum of Hg^{198} and in comparing the spectra of the other isotopes of mercury with that of Hg^{198} the wavelengths of one hundred and twenty-five argon lines in the region 7200–3300 Å were compared with 5460·7532 Å on two or more plates. Seventeen lines well observed both by the authors and by Humphreys (Hu) show (AOW) − (Hu) = ± 0·0000 Å ± 0·0003 Å. Of the twenty-five lines in this region in common with Meggers and Humphreys, four are discordant; for the other twenty-one (AOW) −(MH) = + 0·0012 Å ± 0·0003 Å. Meggers and Humphreys recommend the argon I spectrum as a source of standards; the present results lend support to this recommendation. Wave numbers were deduced by means of Edlén's refraction table. One hundred and five levels were determined and compared with those published by Charlotte Moore. A.

535.338.32

1154. The quenching of mercury resonance radiation (2537 Å) by nitrogen. C. G. MATLAND. *Phys. Rev.*, **92**, 637–41 (*Nov.* 1, 1953).

When a mercury atom in the resonance 6^3P_1 state collides with a nitrogen molecule, it may be transferred to the metastable 6^3P_0 state. The cross-section for this reaction has been measured by a new method. Mercury vapour, in the presence of a known pressure of nitrogen gas, is excited by 2537 Å radiation. After the source of the excitation is cut off, the decay time of the imprisoned radiation is observed. The quenching collision cross-section σ_Q is calculated from the measured decay time and the known value of the imprisonment time in the absence of the quenching gas. Measurements have been taken over the temperature range 325–525°K; σ_Q is found to increase from $5{\cdot}0\times10^{-17}\ \mathrm{cm}^2$ at the lower temperature to $1{\cdot}0\times10^{-16}\ \mathrm{cm}^2$ at the upper temperature. A.

535.338.4

1155. The intensity anomalies in the band-spectrum of CuH. B. KLEMAN. *Ark. Fys.*, **6**, *Paper* 2, 17–24 (1952).

This was photographed when excited at low pressure in a hollow cathode discharge. Intensity anomalies of the same type as was found in the (0–0) band of $^1\Sigma^* - {}^1\Sigma$ by Schüler and Gollnow are shown to be present in the bands belonging to the $^1\Sigma^* - {}^1\Sigma$ and $^1\Sigma^{**} - {}^1\Sigma$ systems. The anomalous intensity distribution in the bands of $^1\Sigma^* - {}^1\Sigma$ is interpreted as being due to a predissociation of $^1\Sigma^*$, and the distribution in $^1\Sigma^{**} - {}^1\Sigma$ as being due to accidental predissociations in $^1\Sigma^{**}$. The non-appearance in the hollow cathode discharge of the bands originating from the $^1\Pi$-states (of about equal energy with $^1\Sigma^*$ and $^1\Sigma^{**}$) is also assumed to be due to predissociation. A.

535.338.4

1156. The emission spectrum of aluminum monofluoride. I. S. M. NAUDÉ AND T. J. HUGO. *Canad. J. Phys.*, **31**, 1106–14 (*Nov.*, 1953).

Two band systems of the emission spectrum of AlF are described, viz. the far ultraviolet $A^1\Pi - X^1\Sigma$ system discovered by Rochester in absorption, and a new system due to a $^1\Sigma - A^1\Pi$ transition in the region 8175 Å–6670 Å. A revised vibrational analysis of the $A^1\Pi - X^1\Sigma$ system is given as well as the vibrational and rotational analyses of the new system, which is the $C^1\Sigma - A^1\Pi$ system of AlF. A.

535.338.4

1157. The band spectrum of nitrogen: new studies of the triplet systems. P. K. CARROLL AND N. D. SAYERS. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1138–44 (*Dec.*, 1953).

Using three different sources the molecular spectrum of nitrogen was investigated in the visible and near infrared. A new infrared system recently reported by Herman has been studied in greater detail and the vibrational analysis revised. It has been shown that the bands do not arise from the singlet transition $v \rightarrow q$ but that states of higher multiplicity are involved. Extensions of the second positive system and the Gaydon–Herman bands in the green are reported. Improved measurements for bands of the First Positive system are given and a new vibrational formula has been derived. A new unassigned band at 8311 Å is reported. A.

535.338.4 : 538.615

1158. The Zeeman effect in the molecular spectra of hydrogen. G. H. DIEKE, S. P. CUNNINGHAM AND F. T. BYRNE. *Phys. Rev.*, **92**, 81–7 (*Oct.* 1, 1953).

The Zeeman effect in the molecular spectrum of hydrogen was observed for all six isotopic species for a field strength of nearly 35 000 gauss. Several thousand lines show modification in the field with many completely resolved patterns. When there is no *L*-decoupling the splittings are represented by the simple theory. When there is *L*-decoupling the splittings may be helpful for the evaluation of the degree of *L*-decoupling and other interactions. Abnormal effects occur for some lines which are related to the Paschen–Back effect in atomic spectra. In a molecular spectrum of this type the observed Zeeman effects are a valuable aid for the classification and interpretation of the lines fully as much as in atomic spectra. A.

535.338.4 : 539.132

1159. A $^2\Delta - {}^2\Pi$-system in germanium hydride (GeH). B. KLEMAN AND E. WERHAGEN. *Ark. Fys.*, **6**, *Paper* 34, 359–67 (1953).

A rotational analysis has been made of a violet band-system 3700–4200 Å which is emitted from a King's furnace containing germanium and hydrogen. This system proves to be a $^2\Delta - {}^2\Pi$ ground-state transition of GeH. The $^2\Delta$-term is regular with small multiplet-splitting and the $^2\Pi$-term regular and near case *a*. The $^2\Delta$-term is predissociated at about $K = 22$ in $v = 0$ and $K = 12$ in $v = 1$. The calculated constants are in good agreement with what can be expected from the corresponding transitions in the hydrides of the carbon group. In addition to this violet system there is an extended red system 5400–7000 Å. A.

535.338.4 : 539.132

1160. A $^4\Sigma^- - {}^2\Pi$-system in germanium hydride (GeH). B. KLEMAN AND E. WERHAGEN. *Ark. Fys.*, **6**, *Paper* 39, 399–405 (1953).

A rotational analysis of the 0, 0 band, excited in a King furnace at about 2300°C, has been made. The rotational constants of the $^4\Sigma^-$ state are: $B_0 = 6{\cdot}775$, $D_0 = 4{\cdot}72 \times 10^{-4}$ cm^{-1}. The splitting in the $^4\Sigma^-$ state is only approximately described by a constant λ for the spin-spin interaction and a constant γ for the magnetic interaction between K and S. [See also Abstr. 4001 (1953) and preceding abstract.]

R. F. BARROW

535.338.4 : 539.132

1161. Analysis of the bands 4–0, 5–1, and 6–2 of the vibration-rotation spectrum of the molecule OH. G. DÉJARDIN, J. JANIN AND M. PEYRON. *Cahiers de Phys., No.* 46, 1–16 (*Nov.*, 1953) *In French.*

The OH bands in the region from 7200–9500 Å, which originate from an oxyacetylenic flame were studied spectrographically. The rotation constants of the levels $v = 4$, 5 and 6, were calculated with the use of Hill and Van Vleck's formula. Λ doubling was observed for P_1 lines; the spread of the terms could be represented by a relation, in good agreement with theory. The vibration terms could be fitted to a formula with four terms. The experimental results are extensively tabulated. A. J. TAYLOR

535.338.4–31

1162. The ultra-violet band-system of silicon monoxide. A. LAGERQVIST AND U. UHLER. *Ark. Fys.*, **6**, *Paper* 10, 95–111 (1953).

A new rotational analysis has been made of the bands, which consist of a single $^1\Pi - {}^1\Sigma$ system, designated $A \rightarrow X$. The following bands were examined: 0,4, 0,3, 0,2, 0,1, 1,0, 1,1, 1,5, 2,0 and 2,6. The constants derived are: $B'_v = 0{\cdot}7272_9 - 0{\cdot}0050_8$ $(v' + \frac{1}{2})$ cm^{-1}, $B''_v = 0{\cdot}6312_8 - 0{\cdot}0069_5$ $(v'' + \frac{1}{2})$, $D'' = 1{\cdot}02 \times 10^{-6}$, $D' = 1{\cdot}43 \times 10^{-6}$, $r''_e = 1{\cdot}509 \times 10^{-8}$ cm, $r'_e = 1{\cdot}620 \times 10^{-8}$ cm, $\omega''_e = 1241{\cdot}4_4$, $\omega'_e = 852{\cdot}7_1$, $\omega''_e x''_e = 5{\cdot}9_2$, $\omega'_e x'_e = 6{\cdot}4_4$. In the upper state several perturbations have been found. They appear to arise from interactions with four electronic states. Three of the perturbing states are singlets, one is a $^1\Sigma^-$, the other two $^1\Pi$ or $^1\Delta$, the fourth one is a $^3\Sigma^-$ state. The analogy with the spectra of CO and SiS is striking. A fair amount of information has been obtained for the $^3\Sigma^-$ state. $\omega_{^3\Sigma^-} \sim 700$ and $B_{^3\Sigma} \sim 0{\cdot}52$ has been found. A.

535.342

1163. Relation between equivalent width and central depth for absorption lines. Analytical formulation of the relation and comparison with observation. R. CAYREL AND S. TAFFARA. *Mem. Soc. Astron. Ital.*, **24**, *No.* 3, 265–74 (1953) *In French.*

For weak, or moderately strong absorption lines it is possible to derive a simple relation connecting equivalent line width, and central depth of absorption (i.e. 1 — central intensity) which will involve wavelength as one parameter. Values computed by the method described agree satisfactorily with those observed for actual line-profiles. D. R. BARBER

535.343–14 : 539.132

1164. Microwave spectra of CsF, CsCl, and CsBr. A. HONIG, M. L. STITCH AND M. MANDEL. *Phys. Rev.*, **92**, 901–2 (*Nov.* 15, 1953).

Molecular constants for CsF, CsCl and CsBr have been determined from measurements of their pure rotational spectra in the microwave region. These and other data allow a test of the constancy of ionic bonding radii. Measurements of isotopic species of these molecules give the mass ratios of the stable Cl and Br isotopes. A.

535.343–15

1165. Substituted methanes. XV. Infrared spectral data, assignments, and calculated thermodynamic properties for fluorotrichloromethane. R. B. BERNSTEIN, J. P. ZIETLOW AND F. F. CLEVELAND. *J. chem. Phys.*, **21**, 1778–80 (*Oct.*, 1953).

Infrared spectral data for gaseous CCl_3F have been obtained in the region 400–3200 cm^{-1}, using NaCl and KBr prisms. The present data are compared with previous Raman and infrared data, and assignments and calculated wave numbers are given. The fundamentals (*=liquid) are $\nu_1(a_1)$ 1085, $\nu_2(a_1)$ 534, $\nu_3(a_1)$ 351,* $\nu_4(e)$ 846, $\nu_5(e)$ 400* and $\nu_6(e)$ 245* cm^{-1}. Thermodynamic properties were calculated for 17 temperatures from 100° to 1500°K and were compared with previous calorimetric results. For Pt XIII, see Abstr. 3120 (1953). A.

535.343–15

1166. Substituted methanes. XVI. Vibrational spectra, potential constants, and calculated thermodynamic properties of dibromodifluoromethane. C. E. DECKER, A. G. MEISTER, F. F. CLEVELAND AND R. B. BERNSTEIN. *J. chem. Phys.*, **21**, 1781–3 (*Oct.*, 1953).

Raman displacements, semiquantitative relative intensities and quantitative depolarization factors of liquid CBr_2F_2, and infrared wave numbers and the percent transmission in the region 450–400 cm^{-1} for gaseous CBr_2F_2 have been obtained. Satisfactory assignments were made for all the observed bands. Using the Wilson *FG* matrix method, with a potential function containing all possible second-degree terms, reasonable values of the potential constants were calculated. Finally, the heat content, free energy, entropy and heat capacity for the ideal gaseous state at 1 atm. pressure were calculated for 12 temperatures, from 100 to 1000°K, using a rigid rotator, harmonic oscillator approximation. A.

535.343–15

1167. Substituted methanes. XVII. Vibrational spectra, potential constants, and calculated thermodynamic properties of diiodomethane. F. L. VOELZ, F. F. CLEVELAND, A. G. MEISTER AND R. B. BERNSTEIN. *J. Opt. Soc. Amer.*, **43**, 1061–4 (*Nov.*, 1953).

Raman displacements, semiquantitative relative intensities, quantitative depolarization factors and wave numbers for the infrared bands in the region 400–3800 cm^{-1} have been obtained for liquid CH_2I_2. A normal co-ordinate treatment was carried out, and a reasonable set of potential constants was determined, using the most general quadratic potential energy function. Assignments were made for all observed Raman and infrared bands. The heat content, free energy, entropy and heat capacity at constant pressure were calculated for 12 temperatures from 100° to 1000°K. A.

535.343–15

1168. Substituted methanes. XIX. C^{13} isotopic shifts in the vibrational spectrum of methanol. R. B. BERNSTEIN, J. E. LAMPORT AND F. F. CLEVELAND. Letter in *J. chem. Phys.*, **21**, 1903–4 (*Oct.*, 1953).

The infrared and Raman spectra of $C^{12}H_3OH$ and methanol containing 9·3 atom % C^{13} have been measured. A C^{13} isotopic shift of about -17 cm^{-1} was observed. G. I. W. LLEWELYN

535.343–15 : 539.132

1169. Conjugation and the intensity of the infrared carbonyl band. G. M. BARROW. *J. chem. Phys.*, **21**, 2008–11 (*Nov.*, 1953).

Data are given for the absolute intensities, in chloroform and carbon tetrachloride solutions and in the vapour state, of the carbonyl infrared absorption bands of a number of compounds in which the carbonyl group is conjugated by varying amounts. The absolute intensity differs in the different solvents and in the vapour, but the increase in intensity of a conjugaged carbonyl over that of a simple ketone or aldehyde seems to be independent of the state. For most of these compounds a simple relation is shown to exist between this increase in carbonyl intensity with conjugation and the resonance energy of conjugation. This relation is expected from a consideration of the electronic configurations available to the normal and distorted molecule. That such compounds as the amides do not necessarily fit this trend is attributed to the geometric requirements on the molecule of these electronic configurations. A.

535.343.2–15

1170. Polarized infrared spectrum of $KAu(CN)_2$. L. H. JONES. Letter in *J. chem. Phys.*, **21**, 1891–2 (*Oct.*, 1953).

Bands at 4270 and 2140 cm^{-1} are assigned and tentative force constants calculated for the Au–C and C–N bonds. G. F. LOTHIAN

535.343.2–15 : 537.311.33

Infrared absorption of the *p*-type germanium. *See Abstr.* 1304

535.343.3–14

1171. Two new lines in the microwave spectrum of heavy water. H. D. CRAWFORD. Letter in *J. chem. Phys.*, **21**, 2099 (*Nov.*, 1953).

A line was found at 8884·83 ± 0·07 Mc/s with estimated absorption coeff. of 2×10^{-6}/cm^3. This is attributed to D_2O. Whether it is the $5_{32} - 4_{41}$ line predicted by others remains uncertain as the Stark spectrum was not resolved. The predicted HDO line at 8835 Mc/s was found at 8837·22 ± 0·12 Mc/s with absorption coeff. 10^{-7}/cm; again high *J*-values are involved. J. JACOBS

535.343.4 : 539.132

1172. *K* fine structure in the $2\nu_1$ band of CHD_3. T. A. WIGGINS, E. R. SHULL, J. M. BENNETT AND D. H. RANK. *J. chem. Phys.*, **21**, 1940–2 (*Nov.* 1953).

The *K* structure in the *P* and *R* branches of the $2\nu_1$ band of CHD_3 has been resolved permitting the determination of the following molecular constants: $\nu_0 = 5865{\cdot}02$, $B'' = 3{\cdot}2777$, $B' = 3{\cdot}2396$, $A' - A'' = -0{\cdot}0181$, $D_J = 3{\cdot}9\times10^{-5}$ and $D_{JK} = -4\times10^{-5}$ cm^{-1}. The *Q* branch is synthesized from these data and compared with the spectrometer trace of that branch. A.

535.343.4–14

1173. Change in the inversion spectrum of ND_3 from resonant to non-resonant absorption. G. BIRNBAUM AND A. A. MARYOTT. *Phys. Rev.*, **92**, 270–3 (*Oct.* 15, 1953)

The absorption due to the inversion spectrum of ND_3 centred near 1600 Mc/s was measured at pressures from 0·3 to 80 cm Hg in the frequency interval

1100 to 2600 Mc/s. The inversion frequency was found to decrease with increasing pressure and became substantially zero at about 9 cm Hg. This change occurs at pressures about 15-fold lower than for NH_3, a result in accord with Margenau's theory. At the higher pressures where the absorption is of the non-resonant or Debye type, the collision diameter is about 6·9 Å, a value roughly one-half that associated with resonant absorption at low pressures. A.

535.343.4–14

1174. One-to-two millimeter wave spectroscopy. II. H_2S. C. A. Burrus, Jr and W. Gordy. *Phys. Rev.*, **92**, 274–7 (*Oct.* 15, 1953).

For Pt I, see Abstr. 4713 (1953). Pure rotational transitions of H_2S^{32}, H_2S^{33}, and H_2S^{34} have been measured with high precision in the region of one to two mm. From these measurements the SH bond length is found to be 1·3226 Å and the bond angle to be 92° 6′. The S^{33} nuclear quadrupole coupling observed along the principal inertial axes are $eQq_{aa} = -32$ Mc/s, $eQq_{bb} = -8$ Mc/s, and $eQq_{cc} = +40$ Mc/s. Approximate analysis of the quadrupole coupling constants shows that the bonding orbitals of S are *spd* hybrids and yields a value of $-0{\cdot}06\times10^{-24}$ cm² for the quadrupole moment of the S^{33} nucleus. From the known ratio Q^{33}/Q^{35} this gives $Q^{35} = 0{\cdot}04\times10^{-24}$ cm². Zeeman studies show that the molecular g_J factor is approximately, but not exactly, equal for different rotational states. A mean value of 0·24 nuclear magneton is found for g_J. A.

535.343.4–15

1175. The ν_2 infrared band in gaseous fluoroform. W. F. Edgell and C. May. Letter in *J. chem. Phys.*, **21**, 1901–2 (*Oct.*, 1953).

Measurements at −170°c sharpen the band and confirm $\nu_2 \simeq 1140$ cm^{-1}. G. F. Lothian

535.343.4–15

1176. The forbidden transition, ν_2, in the infrared spectrum of methane. J. S. Burgess, E. E. Bell and H. H. Nielsen. *J. Opt. Soc. Amer.*, **43**, 1058–60 (*Nov.*, 1953).

A preliminary discussion is given concerning the measurements on the forbidden transition ν_2 in the infrared spectrum of methane, first observed by Coblentz. This band becomes active in the infrared through Coriolis interaction with the frequency ν_4. Although no detailed discussion of the structure of this band can be given before the theory has been studied in detail, many of its characteristics can be accounted for. Finally, with the aid of the value of ν_2*, the corresponding frequency in the infrared spectrum of CD_4, an estimate of the normal frequency ω_2 can be made. A.

535.343.4–15 : 537.29 : 539.133

1177. Infrared absorption induced by static electric fields. M. F. Crawford and I. R. Dagg. Letter in *Phys. Rev.*, **91**, 1569 (*Sept.* 15, 1953).

The absorption of H_2 at 2000 lb/in² in the presence of a static electric field shows four Q branch lines at 4161·2, 4155·1, 4143·0 and 4125·3 cm^{-1} due to the transitions $\Delta\nu = 1$, $\Delta J = 0$ with $J = 0$, 1, 2 and 3 respectively. This confirms Condon's prediction of the effect [*Phys. Rev.*, **41**, 759 (1932)] and from the intensity, $5{\cdot}53\times10^{-29}$ cm^{-1}, per cm path, per molecule per cm³, per (e.s.u. of potential per cm)² the matrix element α_{01} is $1{\cdot}2(5)\times10^{-25}$ cm³ compared with the theoretical value $1{\cdot}393\times10^{-25}$ cm³ [Abstr. 3782 (1952)]. D. H. Whiffen

535.343.4–15 : 539.132

1178. The vibrational spectrum of chlorotrifluoroethylene. D. E. Mann, N. Acquista and E. K. Plyler. *J. chem. Phys.*, **21**, 1949–53 (*Nov.*, 1953).

The infrared spectrum of gaseous F_2C : CFCl has been reinvestigated in greater detail and over a more extensive region than in earlier work. Three hitherto unobserved bands have been found at 369, 338, and 194 cm^{-1}. These data, together with the previously available Raman spectrum, have made possible the achievement of a new and more satisfactory fundamental assignment: 1792 (ν CC), 1336 (ν CF), 1215 (ν CF), 1058 (ν CF), 689 (ν CCl), 517 (δ CF_2), 463 (ρ CF_2), 338 (δ CFCl), 194 (ρ CFCl) for the planar vibrations; and 538 (β CF_2), 369 (β CFCl), 158 (τ) for the out-of-plane models. The ideal-gas entropy value based on the present assignment agrees with that obtained calorimetrically. A.

535.343.4–15 : 539.133

1179. The infrared spectra of the methyl chlorosilanes. A. L. Smith. *J. chem. Phys.*, **21**, 1997–2004 (*Nov.*, 1953).

The infrared spectra of the series $SiCl_4$ through $SiMe_4$ were obtained in the gas phase over the range 2–25 μ using CaF_2, NaCl, and KBr prisms. The spectra are compared with Raman data for these compounds, and vibrational assignments are made. The methyl band at about 8 μ is shown to be associated with the symmetrical CH_3 deformation, the bands around 12 μ with the methyl rocking and Si–C stretching vibrations and the bands between 16 and 25 μ with the SiCl stretching modes. A comparison of frequencies for the members of the series has made it possible to assign fundamentals for all motions except those involving torsion of the Me group around its axis. A.

535.343.4–31

1180. The effect of pressure and temperature on the absorption spectrum of benzene in the near ultraviolet. S. Sambursky, A. Halperin and H. Henig. *J. chem. Phys.*, **21**, 2041–4 (*Nov.*, 1953).

The spectrum of benzene vapour was photographed at temperatures varying from room temperature up to above the critical temperature (287°c), and at the corresponding pressures of the saturated vapour (from a few mm Hg up to about 50 atmos). Changes of the intensity distribution within each of the groups of bands were found, which gave a shift in the maxima of these groups, but even at the highest temperatures and pressures near the critical point no measurable shift in the frequencies of the components of the groups was found. This shows that the effect of intermolecular forces on the frequencies of the bands is very small. A.

535.343.4–31

1181. Absorption bands of SbSe and SbTe in the quartz ultra-violet region 3650 to 2200 Å. C. B. Sharma. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1109–12 (*Dec.*, 1953).

Several new band systems have been observed in the

absorption spectra of SbSe and SbTe molecules in the vapour state at high temperatures (1000° to 1300°C). All the systems lie in the ultraviolet region. The systems have been analysed and constants obtained. A.

535.343.4–32

1182. Absorption of water vapour in the extreme ultraviolet. N. ASTOIN, A. JOHANNIN-GILLES AND B. VODAR. *C.R. Acad. Sci.* [*Paris*] **237**, 558–60 (*Sept.* 14, 1953) *In French.*

The region 200–500 Å was investigated photometrically, at a pressure of $\sim 10^{-2}$ mm Hg and optical path between 50 and 80 cm. The outline of the absorption curve is given, but not the absolute extinction coefficients. There are two regions of strong absorption, one near 340 Å, the other near 260 Å. There is a discontinuity in the curve near 370 Å; this is due to the increasing probability of photo-ionization (fourth potential 33·5 eV). This shows good agreement with the theoretically calculated ionization potential of 32 eV (Mulliken), and also with values obtained by the electron impact method. A. J. TAYLOR

535.343.4–32

1183. Absorption cross-sections in the vacuum ultra-violet. I. Continuous absorption of oxygen (1800 to 1300 Å). R. W. DITCHBURN AND D. W. O. HEDDLE. *Proc. Roy. Soc. A*, **220**, 61–70 (*Oct.* 22, 1953).

Absorption cross-sections for oxygen in the region 1670 to 1360 Å, corresponding to the process $O_2\,{}^3\Sigma_g^- + h\nu \rightarrow O(^3P) + O(^1D)$ have been measured. The cross-section has a maximum value of $1{\cdot}81 \times 10^{-17}$ cm² at 1450 Å and falls to half-value at 1567 and 1370 Å. An account is given of technical methods of quantitative absorption spectrophotometry in this part of the vacuum ultraviolet. A.

535.343.4–32 : 537.564

1184. The photo-ionization cross-section of neon. PO LEE AND G. L. WEISSLER. *Proc. Roy. Soc. A*, **220**, 71–6 (*Oct.* 22, 1953).

The absorption of radiation of wavelength between 230 and 800 Å in neon was measured photometrically in a grazing incidence vacuum spectrograph. For wavelengths longer than that corresponding to the first ionization limit the absorption coefficients were found to be zero except for photo-excitation of resonance transitions. Two sharp absorption edges were observed at 575 and 256 Å corresponding to the L_3- and L_1-edges respectively with a flat maximum between them. The photo-ionization cross-section at the first ionization limit was found to be $5{\cdot}4 \times 10^{-18}$ cm² independent of the pressure between 50 and 500μ; this should be compared with the theoretical value of $5{\cdot}8 \times 10^{-18}$ cm² obtained by Seaton using a dipole-length approximation. Between 575 and 400 Å the calculated and experimental curves agreed closely within the limits of measurement. A.

535.343.4–32 : 537.564 : 535.215.2

1185. Preliminary results on photoelectric yields of Pt and Ta and on photoionization in O_2 and N_2 in the vacuum ultraviolet. N. WAINFAN, W. C. WALKER AND G. L. WEISSLER. *J. appl. Phys.*, **24**, 1318–21 (*Oct.*, 1953).

Absolute photoelectric yields of Pt and Ta and photoionization yields in O_2 and N_2 are reported for the spectral region from 436 to 1004 Å. The experimental methods as well as the monochromator, light source and associated apparatus are described. The results for Pt and Ta give photoelectric yields between 10^{-1} and 10^{-2} electron per photon for wavelengths shorter than 1000 Å. These values are 10 to 100 times larger than those obtained for the same metals between 2000 Å and 3000 Å. Photoionization results for O_2 indicate that below 700 Å almost all absorbed photons produce ion pairs, while in the region between 700 Å and the first ionization limit at 1000 Å the yield varies rapidly. In the case of N_2 at wavelengths shorter than 796 Å, its first ionization limit, the yield rises steeply. Below 725 Å almost all absorbed photons produce ion pairs. The overall error is estimated to be within ±20%. A.

535.345 : 535.39

1186. On determinations of the optical constants of massive metals made using thick layers. D. MALÉ AND P. ROUARD. *J. Phys. Radium*, **14**, 584–7 (*Nov.*, 1953) *In French.*

It is suggested that this method for the measurement of optical constants, whilst avoiding difficulties associated with the preparation of suitable metal surfaces by polishing or other means, is not likely to give the correct values for the massive metal, due to the granular structure of layers even as thick as 500 Å. This is supported by some measurements of the optical constants of layers of Au prepared by sputtering and by evaporation. D. G. AVERY

535.345 : 535.39

1187. Measurement of the reflection, transmission and absorption factors for thin evaporated films of gold. P. ROUARD, D. MALÉ AND J. TROMPETTE. *J. Phys. Radium*, **14**, 587–90 (*Nov.*, 1953) *In French.*

Measurements of these quantities are reported for layers of Au between 0 and 1500 Å in thickness, for three wavelengths in the visible region. In order to avoid differences between films produced in separate evaporations, films of several thicknesses were produced simultaneously by the use of a rotating disk, suitably shaped, placed just below the prismatic glass slides on which the films were deposited. D. G. AVERY

535.345 : 548.7

1188. Optical absorption and photoconduction in the visible and near infrared in single crystals of BaO. W. C. DASH. *Phys. Rev.*, **92**, 68–76 (*Oct.* 1, 1953).

Optical absorption studies of single crystals of BaO indicate the presence of absorption bands at 0·8 and 1·4 eV, induced by ultraviolet or X-ray irradiation at about −160°C. These bands are enhanced about fivefold upon heating a crystal in air to about 1600°C and quenching. Crystals heated in barium vapour have a blue colour and have an absorption maximum at 2·0 eV. Crystals heated in aluminium, magnesium and calcium vapours have similar absorption curves, suggesting that either interstitial barium or oxygen vacancies are responsible for the 2·0 eV absorption. These results, taken together with the results of Redington on diffusion of radioactive barium and of Sproull, Bever, and Libowitz on the diffusion of colour centres in BaO crystals, favour the latter imperfections as the cause of the coloration.

Photoconduction studies, used mainly as a sensitive measurement of optical absorption, show the presence of energy levels at 2·0 and 2·6 eV in addition to those at 0·8 and 1·4 eV. Extensive X-ray irradiation greatly increases the 2·0 eV level photoconduction relative to that of the other bands. A.

535.345 : 548.7

1189. Oxygen vacancies in barium oxide. R. L. Sproull, R. S. Bever and G. Libowitz. *Phys. Rev.*, **92**, 77–80 (*Oct.* 1, 1953).

It has been shown by Dash that an optical absorption band at 2·0 eV occurs in BaO crystals when these are treated in barium or other metal vapours, giving the crystals a blue colour. In order to determine the way the stoichiometric excess of metal is present in the lattice, the diffusion of the blue coloration into BaO has been measured over the range 800°C to 1300°C. The diffusion constant has been found to obey the empirical relation: $D = 2500 \exp(-32\,500/T)$. Comparison of this with Redington's results for the diffusion of Ba^{140} into BaO indicates that the diffusion process giving the coloration does not transport barium. It is concluded that the principal lattice defects in BaO with excess metal are oxygen vacancies, and the absorption band is like the F' band in alkali halides. Chemical determinations of the barium excess are compared with optical determinations. A.

535.345.32

1190. Term splitting by complex binding in rare earths compounds in aqueous solutions. L. Holleck and D. Eckardt. Note in *Naturwissenschaften*, **40**, *No.* 15, 409 (1953) *In German.*

Spectra were taken of various Nd^{+++}, Pr^{+++} and Sm^{+++} complex salts, with the use of a prism spectrograph with rotating sector, as only small interaction between the metal ions and the ions forming the complex was to be expected. The Nd band at 5750 Å and the Pr band at 4819 Å were investigated. The latter corresponds to $^3H_4$–$^3P_0$. The observed splitting must be due to the ground term. A. J. Taylor

535.37

1191. On the luminescence of the thallium (I) and lead (II) halides at low temperatures. H. Gobrecht and F. Becker. *Z. Phys.*, **135**, *No.* 5, 553–7 (1953) *In German.*

The thallous halides, except the fluoride, fluoresce at −180°C under long or short ultraviolet or X-rays, but only if water is present. Grinding alters the fluorescence colours. The corresponding lead halides behave similarly except that grinding effects no fluorescence colour change, and the emission is not so completely eliminated by drying. S. T. Henderson

535.37

1192. On the displacement of the Fermi level by the effect of temperature in phosphorescent sulphides with poison centres. N. Arpiarian. Letter in *J. Phys. Radium*, **14**, 552 (*Oct.*, 1953) *In French.*

In the energy level scheme for ZnS phosphors, the levels above the filled band rise in the order Ag, Cu, Fe, Ni, Co. The Fermi level is between Ni and Co at 300°K, hence Co produces a slow excitation and decay in contrast to the effect of Fe or Ni. At 90°K the Fermi level rises above the Co level and all three poisons show similar behaviour. S. T. Henderson

535.37 : 548.5

Luminescence of activated alkali iodides. *See Abstr.* 1848

535.371

1193. A new method to determine short decay times of phosphors excited with ultraviolet light. A. Bril, H. A. Klasens and P. Zalm. *Philips Res. Rep.*, **8**, 393–6 (*Aug.*, 1953).

A cathode-ray tube is used with ultraviolet-emitting phosphors as light source. The decay time of Sb-activated halophosphates was found to be 5×10^{-6} sec. A.

535.371

1194. Studies on the concept of large activator centers in crystal phosphors. J. Ewles and N. Lee. *J. Electrochem. Soc.*, **100**, 392–407 (*Sept.*, 1953).

I. Dependence of luminescent efficiency on concentration of activator. Size of luminescent centers.

The explanation of the variation of efficiency with concentration of activator in terms of a large centre, given by Ewles, was oversimplified. The recent suggestion of Johnson and Williams that an activator can only function as a luminescent centre if no other activator occupies any of Z lattice sites surrounding it, leads to the same expression for the number of centres as that originally given by Ewles and is effectively based on the same idea. Making use of the experimental findings reported in the present work that lattice defects can act as luminescent centres, and taking into account the competition of centres in the luminescent process, a modification of Ewles' theory of efficiency based on the idea of a large centre leads to the expression $E = K/(1 + \alpha c^{-1} \exp nc)$ for the efficiency. The preparation of two series of calcium oxide phosphors from highly purified and annealed calcium oxide is described. The modified theory is shown to agree well with efficiency measurements on these phosphors and with those quoted by Johnson and Williams, except at high concentrations. Estimates of the "radial extent" of the centres are given.

II. Effects of concentration of activator, of temperature, and of flux on the excitation and emission of CaO : Bi phosphors.

The components of the sharply resolved u.v. band of CaO : Bi, where peak wavelengths can be determined to $\pm 20\,cm^{-1}$, do not show any appreciable shift with concentration of activator or flux, or with temperature. The band is quenched at about 190°K and is replaced by a broad featureless band which increases in intensity up to about 570°K and then decreases. The excitation spectra of CaO : Bi show two peaks (at 2250 and 3470 Å) which show small shifts with temperatures (50 to 75 Å from −193°C to room temperature) and a large change of relative intensity (3 : 1 at −193°C and 1 : 1 at room temperature).

III. Preparation and properties of calcium oxide phosphors with eleven different activators.

Preparation of the phosphors and their emission and excitation spectra are described and discussed. The need for a reducing atmosphere in the case of some activators and the production of a phosphor by heating very pure CaO *in vacuo* are noted and

discussed. In a general discussion, the results reported in the three papers are related to the conception of a large centre. A.

535.371

1195. Researches on luminescent antimony oxide. J. Janin and R. Bernard. *C.R. Acad. Sci.* [*Paris*] **237,** 798–800 (*Oct.* 12, 1953) *In French.*

When sublimed under special conditions crystallized antimony oxide containing manganese shows a green emission with maximum at 5200 Å with excitation bands at 2340 and 2800 Å. Without Mn impurity strong phosphorescence at 4400 is excited by 2340 Å radiation. G. F. J. GARLICK

535.371

1196. Luminescence studies of KI-TlI. B. Smaller and E. Avery. *Phys. Rev.*, **92,** 232–7 (*Oct.* 15, 1953).

The characteristics of the electron traps present in the KI–TlI phosphor have been investigated. Determination of trapping depth and frequency factor yields evidence for representation as a reaction rate process with a division into two distinct trapping systems, while absorption and emission studies indicate a common excited state. Evaluation of concentration and cross-section of traps substantiates the above hypothesis. A.

535.371

1197. Fluorescence of organic single crystals at low temperatures. II. Anthracene, diphenyl, acenaphthene. P. Pesteil and M. Barbaron. *C.R. Acad. Sci.* [*Paris*] **237,** 884–6 (*Oct.* 19, 1953) *In French.*

For Pt I, see Abstr. 6658 (1953).

535.371 : 537.533.7

1198. The penetration of electrons into luminescent material. W. Ehrenberg and J. Franks. *Proc. Phys. Soc.* [*London*] *B*, **66,** 1057–66 (*Dec.*, 1953).

The penetration of electrons of energies between 10 and 40 keV into a number of phosphors, and the extent of their scattering, was measured on microphotographs of the luminous region produced in the phosphor by a beam of electrons of less than 0·75 μ diameter. A description is given of the apparatus and of the electron optical system designed to produce the fine focal spot. The phosphors used in the experiment were single crystals of the thallium-activated iodides of K, Rb and Cs, and of the tungstates of Ca and Cd, and a luminescent plastic. An attempt is made to account for the discrepancies in the electron ranges as found in the present experiments compared with those obtained by other methods. An estimate is made of the distribution in depth of the energy dissipation in a phosphor when bombarded by a beam of electrons. A.

535.372

1199. A new 6100-Å band in zinc orthosilicate activated with manganese. P. Zalm and H. A. Klasens. *Philips Res. Rep.*, **8,** 386–92 (*Oct.*, 1953).

When phosphorus is incorporated together with manganese into zinc orthosilicate at low temperatures a phosphor is obtained with an emission band at 6100 Å next to the normal green Mn emission at 5250 Å. The properties of this new emission band are discussed and compared with those of similar bands in other manganese-activated zinc silicates. A.

535.372 : 535.343

1200. n–π emission spectra. C. Reid. Letter in *J. chem. Phys.*, **21,** 1906 (*Oct.*, 1953).

The phosphorescence of molecules containing a hetero-atom with an unshared pair of electrons adjacent to a conjugated system may be due to singlet n–π transitions, triplet n–π transitions and triplet π–π transitions. Differentiation between these transitions can be made from the observed emission spectrum of the substance. G. I. W. LLEWELYN

535.375.5

1201. Intensity problems in the first-order Raman effect. O. Theimer. *Acta phys. Austriaca*, **7,** *No.* 3, 216–38 (1953) *In German.*

Intensities depend on the derivatives of the polarizabilities. The paper tabulates, for various point groups, the components of the derivatives that are non-zero, together with the transformation matrices for various symmetry operations.

G. F. LOTHIAN

535.375.54 : 548.736.5

1202. Optical properties and crystal structure of $KHCO_3$. L. Couture-Mathieu. *J. Phys. Radium*, **14,** 625–6 (*Nov.*, 1953) *In French.*

The disagreement between conclusions drawn from optical and Raman effects [Abstr. 984 (1951)] and those drawn from X-ray analysis [Abstr. 6204 (1952)] are removed by correcting the relation between the morphological and X-ray axes. Groth's axes, formerly supposed to be **a**, **b**, 2**c**, are actually **a** + 2**c**, −**b**, −2**c**. A. J. C. WILSON

535.376/.377

1203. A note on the analysis of first-order glow curves. L. I. Grossweiner. *J. appl. Phys.*, **24,** 1306–7 (*Oct.*, 1953).

Simple equations are developed which permit the calculation of the trap depth and frequency factor of first-order glow curves from the temperatures of the peak and the half-height. The equation for the trap depth does not depend explicitly on the frequency factor or the heating rate and is accurate to 5% over a wide range. Application is made to theoretical glow curves and to an experimental glow curve obtained from the thermoluminescence of ice. A.

535.376

1204. On the mechanism of electroluminescence. I. Theoretical considerations. D. Curie. *J. Phys. Radium*, **14,** 510–24 (*Oct.*, 1953) *In French.*

A detailed discussion in terms of the movement of electrons in a luminescent crystal, their origin, acceleration, path length and collision with centres or traps. The mechanism proposed includes (1) the supply of electrons to the conduction band from donor levels emptied by the applied field; (2) the acceleration of these electrons by a process analogous to dielectric breakdown; and (3) the loss of energy of the electrons by collision with centres to produce electroluminescence, or with filled traps to give the extinctive effect (Gudden and Pohl). It is shown that fields of the order of 10^4 V/cm should be adequate to evoke electroluminescence by this mechanism, the main theoretical difficulties being in stage (1).

S. T. HENDERSON

535.376 : 537.542

1205. Luminescence and the scintillation counter. S. C. CURRAN. *London: Butterworths Scientific Publications* (1953) 205 + xciii.

Review in *Phil. Mag.*, **44**, 1411 (*Dec.*, 1953).

535.39

1206. Application of matrix methods to the calculation of complex assemblies of alternating thin films. C. DUFOUR AND A. HERPIN. *Optica Acta*, **1**, 1–8 (*Jan.*, 1954) *In French.*

This paper gives methods for the rapid calculation of the properties of stratified thin layers of non-absorbing material of equal thickness, both of the type HB HB HB and of the more complicated type HB HB–D–H′B′ H′B′ H′B′. The results are presented in a form suitable for practical use, and are illustrated by experimental results, for both normal and oblique incidence. A.

535.417

1207. An optical calcite interferometer with wavelength independent intensity-equalization. H. SCHOPPER. *Z. Phys.*, **135**, *No.* 5, 516–22 (1953) *In German.*

A beam of plane polarized light passes in turn through 2 plane parallel calcite plates of interferometrically equal thickness, oriented with their principal planes perpendicular to one another. There emerge 2 separated beams which are in exactly equal phase for all wavelengths. If the beams are reflected back again they recombine to a single plane polarized beam. If one suffers a phase change at reflection, the beams recombine to give an elliptically polarized beam; analysis of this with a Babinet compensator gives a measure of the phase change produced at the reflection. Such measurements have been made on a back silvered fused silica plate, with a precision of $\pm 3°$ through the visible spectrum. G. F. LOTHIAN

535.417

1208. Better resolution by using suitable apertures. M. S. SODHA. Letter in *Curr. Sci.*, **22**, 263–4 (*Sept.*, 1953).

The author suggests two types of aperture for use with a Lummer–Gehrcke plate for improving resolution at the expense of a slight loss in intensity. The resolution with N beams of equal intensity is greater than that obtained with N beams of slowly diminishing intensity. The apertures are shaped so that the increase in width of the emergent beams compensates for the loss in intensity due to successive reflections and absorptions in the plate. R. W. FISH

535.417

1209. The second-order aberrations in the interferometric measurement of concentration gradients. H. SVENSSON. *Optica Acta*, **1**, 25–32 (*Jan.*, 1954).

The second-order aberrations in interferograms of cells with a continuously varying refractive index have been computed for those interferometric methods where an optical image of the cell is produced. The aberration corresponding to the Wiener skewness of the gradient curve disappears if a plane situated $\frac{1}{4}$ of the cell thickness from the front wall is brought into focus by the camera. The off-axis position of the light source is without bad effects, resulting only in a small parallel shift of the interferogram as a whole along the cell axis. An illumination system which gives converging or diverging light through the cell gives rise to an aberration which can be corrected for by determining the optical magnification factor of the cell from the slightly defocused plane through the middle of the cell. A vertically extended light source causes blurring of fringes lying close together, which only disappears if the middle of the cell is brought to focus. It is pointed out that, using a very sharp boundary in the cell, this property offers excellent means of accurate localization of the conjugate image plane of the plate, which should be useful in different connections in optical adjustment and testing of lenses. On the whole, it has been found that all sorts of second-order aberrations can be eliminated by a proper choice of optical arrangements, adjustments and procedures, which are described and specified. The only exception is the case where very rapid diffusion processes or other circumstances make it necessary to use a vertically extended light source in order to get the necessary light intensity for a short exposure time. It will then be necessary to focus on the middle of the cell in order to get sharp fringes. The fringe displacement corresponding to the Wiener skewness will then remain and has to be corrected for. A.

535.417 : 535.317

1210. Application of interference by double refraction to the study of aberrations. M. FRANÇON AND M. JORDERY. *Rev. Opt.*, **32**, 601–9 (*Nov.*, 1953) *In French.*

A very simple interference method is given for the study of aberrations with white light and with approximately monochromatic light. The object being outside the interferometer, test of large surfaces with a very small interferometer is possible. The interferometer is a polarizer system with a Savart polariscope and needs no accurate adjustment. A.

535.417–14/15

1211. Interferometers in microwave- and infrared-spectroscopy. J. C. VAN DEN BOSCH AND F. BRUIN. *Nuovo Cimento*, **9**, *Suppl. No.* 3, 245–50 (1952).

A wide discussion of possible uses for measurements of refractive indices, frequency, loss factors, etc., and for stabilizing klystrons. D. H. WHIFFEN

535.42 : 534.321.9

1212. Diffraction of light by ultrasonic waves. I. General theory. A. B. BHATIA AND W. J. NOBLE. *Proc. Roy. Soc. A*, **220**, 356–68 (*Dec.* 8, 1953).

Following Darwin's (1924) treatment of the reflexion and refraction of light on a transparent homogeneous medium, the problem of the diffraction of light by ultrasonic waves is formulated in terms of the scattering of electromagnetic waves by a periodically perturbed medium. This leads to an integral equation which has been solved for E-polarization with the help of a trial solution for the electric disturbance in the medium in the form of a double infinity of plane waves. The condition that the trial function be a solution of the integral equation leads to (*a*) the frequencies and the directions of the diffracted spectra, and (*b*) three infinite sets of linear algebraic equations for the amplitudes N_{lm} and other

unknowns occurring in the trial solution. The expressions for the intensities of the diffracted spectra involve the various unknowns of the trial function and can be immediately written down once these unknowns have been determined from the equations. A.

535.42 : 534.321.9

1213. Diffraction of light by ultrasonic waves. II. Approximate expressions for the intensities and comparison with experiment. A. B. BHATIA AND W. J. NOBLE. *Proc. Roy. Soc. A*, **220**, 369–85 (*Dec.* 8, 1953).

In Pt I the problem of calculating the intensities of the various orders in the diffracted spectra was reduced to one of solving three infinite sets of linear algebraic equations. Pt II deals with the approximate solutions of these equations and the calculation of intensities for some specific cases. It is shown that it is possible to solve these equations (and thence calculate the intensities) to any degree of accuracy over the entire range of experimental conditions, i.e. for any $\delta = \Delta\Lambda^2/\lambda^2$ and angle of incidence θ. Here Δ is the ratio of the maximum density change to the average density of the medium, Λ is the wavelength of the sound wave in the medium and λ the vacuum wavelength of the incident light. For $\delta \ll 1$ or $\delta/\xi \ll 1$, where $\xi = \Lambda \sin\theta/\lambda$, the solution of these equations is particularly simple. Under these conditions only one or two orders are likely to appear on either side of the transmitted beam and expressions for their intensities are obtained. For larger δ ($\delta \sim 1$ or > 1) and δ/ξ not $\ll 1$, the solution of the equations is complicated, but it is shown that for any given δ and θ, only a finite number (at most ~ 20 from each set and ordinarily considerably less) of these equations suitably chosen need be considered. One is also able to deduce the number of orders likely to appear under given experimental conditions. In particular, the well-known asymmetry in the diffracted spectra for oblique incidence receives a natural explanation. These and various other results of the theory are in satisfactory agreement with experimental data. Finally, if one makes approximations similar to those made by Raman and Nath in their theory for large δ, the present theory also gives for the intensity of a given order l, J_l^2, where J_l is the Bessel function of order l. This approximation, it is shown, overestimates the intensities in higher orders. A.

535.42 : 535.8

1214. The functional conditions for instrumental diffraction. Particular case of the amplitude zeros in diffraction figures of revolution. G. LANSRAUX. *Cahiers de Phys., No.* 45, 29–39 (*Sept.*, 1953) *In French.*

The analytical conditions are derived that must be satisfied by the functions representing the complex amplitudes in the meridional sections of an arbitrary pupil and the corresponding diffraction figures. It is shown that they can be represented by polynomials and their associated functions to any required degree of precision. The results are applied to the study of the amplitude zeros in the diffraction figure of a perfect optical instrument, fitted with an amplitude filter and correctly focused. R. W. FISH

535.43

1215. The refractive index [n] correction in light-scattering measurements. D. J. MEIER. Letter in *J. chem. Phys.*, **21**, 1892–3 (*Oct.*, 1953).

Measurements confirm the theory of Hermans and Levinson [Abstr. 6901 (1951)] that the correction factor with a conical cell is n^2. G. F. LOTHIAN

535.43

1216. Rayleigh scattering of condensed matter. O. THEIMER AND E. LELL. *Canad. J. Phys.*, **31**, 1170–81 (*Nov.*, 1953).

The scattering power $S(\lambda) = I_s/I_d$ (I_s, I_d are the intensities of the scattered and the incident light) for visible light is investigated experimentally for ordinary glass, optical glass, water, and air. It is found that $S(\lambda)$ for glass shows pronounced deviations from Rayleigh's $1/\lambda^4$ law, e.g., a relative maximum of $S(\lambda)$ for $\lambda = 5200$ Å in the case of ordinary glass. A theory for the Rayleigh scattering of condensed matter is developed and compared with the ideas brought forward by Fürth and Humphreys-Owen in 1951. It is shown that the maxima of $S(\lambda)$ observed by these authors and in the present work can be equally well derived from localized lattice imperfections or from the mosaic blocks considered by Fürth. A.

535.434

1217. Some aspects of light scattering from polydisperse systems of spherical particles. E. ATHERTON AND R. H. PETERS. *Brit. J. appl. Phys.*, **4**, 344–9 (*Nov.*, 1953).

The simple theory of light scattering, as developed by Debye, is discussed and its application to polydisperse systems of spherical particles examined. Three measurements are possible, namely, dissymmetry, turbidity and the relation of the latter with wavelength. By employing model distributions these three parameters of the scattering may be calculated and the averages values for the diameter given by them studied. The dissymmetry ratio, whilst giving an indeterminate average, leads to values of the diameters which approximate to the weight average given by the turbidity technique. The wavelength dependence of turbidity gives a diameter which approximates to the mean of the distribution. A.

535.434

1218. Light scattering measurements on polydisperse systems of spherical particles. E. ATHERTON AND R. H. PETERS. *Brit. J. appl. Phys.*, **4**, 366–9 (*Dec.*, 1953).

The application of Debye's theory to polydisperse systems of spherical particles is discussed and light scattering measurements have been made using some commercial dispersions. Three methods have been employed, namely, measurement of the dissymmetry, the turbidity and the dependence of the latter on wavelength. The first two give a weighted average whilst the latter gives an approximation to the mean. From these averages the particle size distributions of two dispersions have been determined assuming them to be normal. The distribution curves compare favourably with those obtained by direct means employing the electron microscope. A.

535.515 : 539.216.1

1219. Birefringence of synthetic fibres. I. G. Bozza. *Nuovo Cimento*, **10**, *Suppl. No.* 1, 1–23 (1953) *In Italian.*

Using a method similar to that employed in the case of birefringence of a flowing liquid, the optical anisotropy of a fibre is considered, assuming a known orientation distribution of the submicroscopic elements: micelles, packets or single macromolecules. The orientation of an element is defined by the angles between its axis and the co-ordinate axes, and the polarization possibility is expressed as an integral tensor. The theory is developed and applied to some special cases, such as uniform, ellipsoid, sinusoidal distributions. Kratky's hypothesis of rectilinear elements is discussed. J. A. WILCKEN

535.515 : 539.216.1

1220. Birefringence of synthetic fibres. II. G. Bozza and E. Bonauguri. *Nuovo Cimento*, **10**, *Suppl. No.* 1, 24–54 (1953) *In Italian.*

To test the theory, cross-sections of threads of a fibre, taken at intervals of 0·5 mm, were examined under microscope and the max. optical-path differences were measured together with the diameters. The fibre threads showed surprising non-uniformity. The discrepancy between the theoretical and experimental relation between birefringence and swelling is explained as due to irregularity of swelling. The results are discussed at length. J. A. WILCKEN

535.55

1221. Maxwell effect in some simple organic liquids: comparison between theory and experiment. T. S. Narasimhamurty. *Proc. Indian Acad. Sci. A*, **35**, 126–8 (*March*, 1952).

Little agreement seems to hold between the mechanical birefringence experimentally observed by different workers and that calculated using the formula of Raman and Krishnan. G. I. W. LLEWELYN

535.55 : 534.25

1222. Acoustic birefringence of liquid polystyrene. G. S. Bennett and D. A. Hall. Letter in *J. Acoust. Soc. Amer.*, **25**, 1014–15 (*Sept.*, 1953).

Preliminary data of an extended programme on acoustic birefringence are presented, showing the existence of such birefringence in poly-alpha-methylstyrene at a frequency of 1000 kc/s, and that a linear relation exists between the magnitude of birefringence and transducer current. A.

535.551 : 539.37

1223. The relation between stress, strain and birefringence in some high polymers. S. M. Crawford. *Proc. Phys. Soc.* [*London*] *B*, **66**, 884–6 (*Oct.*, 1953).

Simultaneous measurements of the birefringence, stress and strain in crystalline and amorphous Terylene have been made at different temperatures. The results are compared with those obtained for polyethylene and Perspex where the birefringence is a single-valued function of strain. It is found that, for both the crystalline and amorphous forms, the birefringence is a function of both stress and strain and, for small strains, can be represented by an equation of the form $\Delta n = A\sigma + B\varepsilon$, where Δn is the birefringence, σ the stress, ε the strain and A and B are constants. The behaviour of these polymers is discussed in terms of this equation. A.

535.7 : 612.84

Physiological optics. *See Abstr.* 1928–31

535.8

1224. Method of controlling profiles. A. Mirau. *Rev. Opt.*, **32**, 418–22 (*July*, 1953) *In French.*

Control method for machining profiles, giving about 0·01 mm accuracy for pieces several centimetres in size. A.

535.8

1225. Recent developments in applied optics. A. C. Menzies. *J. sci. Instrum.*, **30**, 441–52 (*Dec.*, 1953).

In the last ten years, there have been many advances in applied optics, side by side with a considerable improvement in optical instruments. This progress has been mainly due to the application of electrical methods of detection of radiation, and in part to advances in other fields of physics. Optical methods have been increasingly introduced into industry, for control as well as for measurement. Where visible radiation is concerned, the improvement is in convenience rather than in sensitivity. The selection of examples is arbitrary, but it is sufficiently diverse to illustrate the breadth of application of optics and the considerable progress which has been made. A.

535.81 : 771.351

1226. A method for the determination of the principal focus and the focal length of photographic lenses for the infrared. H. Naumann. *Optik*, **10**, *No.* 9, 413–22 (1953) *In German.*

A concave mirror is used as a collimator, with a scaled test object in the focal plane at a small angle to the optical axis. The zero mark on the scale is adjusted by auto-collimation to give emergent parallel light for the visible region. Photography with a lens mounted in a camera, and the scale illuminated by infrared allows the i.r. focal position to be determined from the scale reading with best definition. A double test object allows the i.r. focal length to be determined. Measurements on typical lenses are quoted. R. W. FISH

535.822

1227. The elimination of disturbing structures during light-slit microscopy by vibrating the object. E. Menzel. Note in *Naturwissenschaften*, **40**, *No.* 18, 480–1 (1953) *In German.*

In the examination of surfaces with the multiple slit Schmalz microscope, surface irregularities often are shown with enhanced contrast even though they are small compared with the surface profile being measured. Vibration of the test object in the plane of the surface and in a direction at right angles to the light slits removes many of these disturbances. Practical details and sample photographs are given. R. W. FISH

535.822.6

1228. Study and application of a polarization interferometer. M. Françon. *Optica Acta*, **1**, 50–8 (*Jan.*, 1954) *In French.*

An interferometer is described formed by two quartz plates cut at 45° to the axis and crossed, and interposed between two polarizers. A very simple

arrangement for converting the ordinary microscope with its normal objectives into an interference microscope is achieved. By small variations of the inclination of the interferometer, transparent objects can be observed with or without coloured contrast. The interference eye-piece can be used without modification for the metallurgical microscope. Some microscopic applications of the interferometer are given. One of them gives a very simple method for the study of reflecting objects. A.

535.824.2

1229. A special objective with large numerical aperture. J. Lefaivre. *Canad. J. Phys.*, **31**, 1182–4 (*Nov.*, 1953) *In French.*

A dry objective of numerical aperture 0·84 has been computed for special purposes. It is a catadioptric objective of the centred type, after the terminology of Bouwers. It is not achromatic. A.

535.83 : 771.351

1230. Suggestion for an improved telephoto objective. H. O. Hoadley. Letter in *J. Opt. Soc. Amer.*, **43**, 923 (*Oct.*, 1953).

A fluorite objective is recommended as the first component of a telephoto lens, since it has a large positive Petzval sum and very small zonal spherical aberration, chromatic variation of spherical aberration, and secondary spectrum. R. W. FISH

HEAT 536

536.2

1231. An apparatus for the measurement of the thermal conductivity of biological tissue. H. S. Hatfield. *J. sci. Instrum.*, **30**, 460–1 (*Dec.*, 1953).

The thermoelectric tellurium-silver heat-flow meter disk [Abstr. 2427 (1950)] is applied to determining the thermal conductivity of soft and moist material such as biological tissue. A disk of tissue 15 mm in diameter, 3 mm thick, is sandwiched between two meter disks in a cylindrical cup under oil. A heater at the bottom of the cup creates a current of heat through the disks; a heater winding round the periphery of the cup prevents horizontal flow of heat, being adjusted until the reading of the two heat meters is the same. Differential thermocouples measure the gradient across the specimen. The apparatus has been employed on a series of measurements of human and animal tissues. A.

536.21

1232. Apparatus for the measurement of the thermal conductivity of solids. J. L. Weeks and R. L. Seifert. *Rev. sci. Instrum.*, **24**, 1054–7 (*Nov.*, 1953).

An apparatus has been developed with which thermal conductivities can be measured in the temperature range from 40°c to 100°c with a probable error of $\pm 0{\cdot}003$ cal sec^{-1} cm^{-1} deg^{-1} or $\pm 3\%$, whichever is the larger. It requires only a small sample ($0{\cdot}1875 \times 0{\cdot}1875 \times 1{\cdot}75$ in.), does not require the attaching of thermocouples to the sample, and permits introduction and removal of the sample by remote control, if this is necessary. The apparatus is therefore especially useful to measure the thermal conductivity of large single crystals and also to observe the effect upon thermal conductivity of heat treatment, irradiation, or any other treatment that will not deform the sample yet which cannot be carried out readily with thermocouples attached to the sample. A.

536.21 : 548.7

1233. The thermal conductivity of diamond at low temperatures. R. Berman, F. E. Simon and J. M. Ziman. *Proc. Roy. Soc. A*, **220**, 171–83 (*Nov.* 10, 1953).

The thermal conductivity of a type I diamond has been measured between 2°K and room temperature. Above 100°K the temperature variation of conductivity accords with Peierls's theory of Umklapp processes. To account for the results at the lowest temperatures it is necessary to assume that some specular reflection of phonons occurs at the crystal boundaries. Casimir's theoretical treatment of boundary scattering has been extended to take into account the finite length of specimens and the smoothness of the crystal walls, and the experimental results show that at 3°K the proportion of specular reflections is as great as 40%. Between 50 and 100°K the conductivity is considerably less than that calculated for an ideal diamond, and some conclusions are drawn as to the imperfections which cause this discrepancy. A.

536.212 : 539.11

1234. The influence of exchange forces on the thermal conductivity of metals. M. Kohler. *Abhandl. Braunschw. Wiss. Gesell.*, **5**, 48–52 (1953) *In German.*

The electron theory of metals predicts, that for $T > \Theta_D$ the Wiedemann–Franz number L has the universal value $2{\cdot}445 \times 10^{-8}$ (Volt/Grad)^2. For the alkali-metals Na and K the experiment value for L is nearly 10% lower. As explanation for this fact the influence of electronic exchange-forces is considered. These forces diminish the electronic heat below the Sommerfeld value. For description of the potential between two electrons the form $(e^2/r)\exp(-\mu r)$ is used. In the case of Na good numerical agreement with experiments is obtained if the value of μ is taken from Landsberg's theory of X-ray emission-bands (1949). A.

536.212.2

1235. The thermal conductivity of magnesium at low temperatures. W. R. G. Kemp, A. K. Sreedhar and G. K. White. Letter in *Proc. Phys. Soc.* [*London*] *A*, **66**, 1077–8 (*Nov.*, 1953).

Reports measurements of conductivity, K, on one "as drawn" and two annealed pure specimens. Effect of annealing is to increase maximum K by about 40%. The theoretically predicted minimum at $T \simeq \theta/4$ is not found and the results suggest an increase below 5°K of T/K as the temperature is lowered. A brief comparison is made with theory. F. E. HOARE

536.212.2 : 537.311.31 : 536.48

1236. The thermal and electrical conductivity of magnesium at low temperatures. H. M. Rosenberg. *Phil. Mag.*, **45**, 73–9 (*Jan.*, 1954).

The electrical and thermal resistivities of the same specimen of magnesium have been measured together

between 2 and 35°K. The electrical resistance had a minimum at 6°K and an effect of a similar order of magnitude occurred for the thermal resistance W. This is best demonstrated by plotting a graph of WT against T^3 which shows a marked departure from linearity in the region of the electrical resistance anomaly. A.

536.212.2 : 537.311.33

Electronic thermal conduction in superconductors. *See Abstr.* 1305

536.41

1237. The thermal expansion of anisotropic metals. B. G. CHILDS. *Rev. mod. Phys.*, **25**, 665–70 (*July*, 1953).

A review of the present state of knowledge of the variation with temperature of the thermal expansion of anisotropic metals. The theoretical significance of the experimental data is discussed. A.

536.413.2

1238. The measurement of the thermal expansion of single crystals of indium and tin with a photoelectric recording dilatometer. E. V. VERNON AND S. WEINTROUB. *Proc. Phys. Soc.* [*London*] *B*, **66**, 887–94 (*Oct.*, 1953).

An improved form of the interferometric dilatometer of Childs and Weintroub [Abstr. 4912 (1950)] is described briefly and shown diagrammatically. The expansion and temperature fringes are recorded simultaneously and automatically by means of photomultipliers. The interferometer plates are coated with reflecting films and the dilatometer is suitable for crystals of approximately 2 cm length. The thermal expansions of two tin single crystals of orientations $\psi = 8$ and $65{\cdot}5°$ were recorded over the temperature range 30–180°c, and of seven indium single crystals, $\psi = 7$–$82°$, over the range 30–120°c. The linear expansion coefficients α_ψ were calculated from the records and the two principal coefficients $\alpha_{||}$ and $\alpha_\perp$ corresponding to $\psi = 0$ and 90° were then found by extrapolation. For indium, $\alpha_{||}$ and $\alpha_\perp$ change steadily from $-7{\cdot}5$ and $50{\cdot}0\times10^{-6}$/deg. c at 30°c to $-29{\cdot}0$ and $72{\cdot}5\times10^{-6}$/deg. c at 120°c respectively. The errors in $\alpha_{||}$ and $\alpha_\perp$ are estimated to be not greater than 5 and 1% respectively. The results are exhibited in graphical and tabular form. The single crystals were grown by the method of slow solidification from the melt. A.

536.421.1

1239. On the solid-liquid transformation in metals. G. BORELIUS. *Ark. Fys.*, **6**, *Paper* 20, 191–206 (1953).

Thermodynamic calculations based on the assumption of continuity between the solid and liquid states and simple assumptions about the separation of the internal energy of metals into parts of vibrational and structural origin, lead to new possibilities of interpretation of the sub-coolability of liquid metals and of the thermal expansion phenomena. A.

536.422.1

1240. A study of the propagation mode for metallic vapors in shadow-casting by vacuum evaporation of Au^{198} and Cr^{51}. L. E. PREUSS. *J. appl. Phys.*, **24**, 1–9 (*Nov.*, 1953).

A special method is introduced for quantitatively determining the metal-evaporation mechanism using metallic gold and chromium tagged with pile-produced Au^{198} and Cr^{51}. This tracer method provides a powerful tool for the study of the distribution of minute amounts of the evaporated metal. Propagation and deposition of the vaporized metal are analysed under a variety of conditions both in the normal evaporation process and for shadow-casting conditions. It is shown that crucible size and shape determine the evaporation-dispersion pattern. Computation of film thickness is by quantitative tracer methods with correlating observations by electron microscopy. The probable error of the method is $\pm2\%$. A.

536.423.4

1241. The theory of condensation of supersaturated vapours in the absence of ions. A. J. BARNARD. *Proc. Roy. Soc. A*, **220**, 132–41 (*Oct.* 22, 1953).

A brief review of the condensation theory of Becker and Döring (1935) and Frenkel (1946) is given. It is shown that the theory is subject to the limitation that it assumes that small molecular complexes behave like liquid droplets. This is not the case for complexes consisting of a few molecules only, so that the rate of condensation expected from the theory may be altered by an appreciable amount. The Becker and Döring expression for critical supersaturation is compared with the cloud-chamber measurements of Volmer and Flood (1934), taking into account the rapid heating of the gas after the fast expansion. It is found to be in approximate agreement for water and some of the alcohols, but methyl alcohol, benzene and carbon tetrachloride show large discrepancies. More measurements of critical supersaturations are needed. A.

536.424

1242. The transition points of anhydrous potassium carbonate. Comparison with sodium carbonate. J. JAFFRAY AND P. MARTIN. Letter in *J. Phys. Radium*, **14**, 553 (*Oct.*, 1953) *In French.*

Microcrystalline K_2CO_3 was investigated by the same methods as Na_2CO_3 [see Abstr. 6713 (1953)]. Two transition points were found at 410°c and 465°c. Contrary to Na_2CO_3 both transitions showed continuity of volume, practically no latent heat, and there was no notable change in the crystal lattice between room temperature and 500°c. Both transitions accordingly are of the second order, and are shown by anomalies in specific heat and thermal expansion coefficient. The transitions are not perfectly reproducible, but vary up to 6°c. These irregularities are particularly noticeable in measurements of electric conductivity. For Na_2CO_3 the variations are very much smaller. A. J. TAYLOR

536.46 : 537.566

1243. Ionization in cold flames. W. JOST AND H. G. WAGNER. Note in *Naturwissenschaften*, **40**, *No.* 16, 435 (1953) *In German.*

Reports measurements on cold ether-oxygen flames (200–700 mm Hg pressure, about 400°c) which show ionization densities $\lesssim 2\times10^4$/cm^3. Different forms of the flames are very briefly described.

J. D. CRAGGS

536.48

1244. A new theory of liquid helium: further treatment. H. N. V. Temperley. *Proc. Phys. Soc.* [*London*] *A*, **66**, 995–1008 (*Nov.*, 1953).

A treatment is given that is a simplified version of that in Abstr. 8135 (1952). The assembly, consisting of vapour and liquid, is treated as an equilibrium mixture of aggregates of all sizes, an aggregate being defined as a number of atoms which together form a bound quantum-mechanical state. By making plausible assumptions about the energy levels of these aggregates a model is found which shows both liquefaction and a generalized Bose condensation. The model seems to be a satisfactory compromise between the points of view of Landau and of London and Tisza, and leads to a synthesis of their two explanations of the appearance of superfluidity. It also provides a physical basis for the model assumed by F. London in 1939. A.

536.48 : 539.152.2

1245. Temperature dependence of the nuclear susceptibility of He^3 between 1·2°K and 4·2°K. W. M. Fairbank, W. B. Ard, H. G. Dehmelt, W. Gordy and S. R. Williams. Letter in *Phys. Rev.*, **92**, 208 (*Oct.* 1, 1953).

Using a magnetic field of 10 000 gauss and a frequency of approx. 30 Mc/s, the authors observed magnetic resonance in He^3 gas at 4·2° and 900 mm in liquid He^3 between 1·2 and 2·8°K. In these experiments helium was enclosed in a coil forming part of a resonance receiver circuit. The nuclear susceptibility of He^3 is derived from the intensity of the response. It is found that the susceptibility is proportional to the reciprocal absolute temperature in accordance with classical statistics. There is no indication of an antiparallel alignment of nuclear spins such as is appropriate to an ideal degenerate Fermi-gas. R. EISENSCHITZ

536.48

1246. Classical considerations on the abnormal properties of helium-4. S. F. B. Tyabji. *Nature* [*London*] **172**, 849–50 (*Nov.* 7, 1953).

It is assumed that in liquid He the mechanism of momentum transfer is the same as in gases and that the thermal agitation consists mainly of longitudinal waves of wavelengths comparable with the width of slits or capillaries. It is asserted that in flowing He the wave propagation across the slit breaks down at very short distances from the inlet. This phenomenon is claimed to suffice for explaining almost all peculiar properties of He II without invoking the quantum theory. Reasons are given according to which this argument must not be applied to the He isotope of mass 3. R. EISENSCHITZ

536.48 : 532.61

1247. The surface tension of liquid helium. K. R. Atkins. *Canad. J. Phys.*, **31**, 1165–9 (*Nov.*, 1953).

Following a suggestion due to Frenkel, the normal modes of a liquid helium surface are taken to be surface tension waves. The free energy associated with these modes is estimated and is found to give a major contribution to the temperature dependence of the surface tension of liquid helium II. The zero-point energy of the modes is shown to be an appreciable fraction of the total surface energy at 0°K. A.

536.48

1248. The thickness of the saturated helium II film. R. Bowers. *Phil. Mag.*, **44**, 1309–21 (*Dec.*, 1953).

The average thickness of the saturated He II film on an aluminium foil has been measured by a gravimetric method. For the film in contact with the bulk liquid, values between 120 and 180 atomic layers ($4{\cdot}8\times10^{-6}$ cm and $7{\cdot}2\times10^{-6}$ cm) have been observed, depending on the height of the specimen above the bulk liquid level. The average thickness is independent of temperature except within 0·006 degree of the λ-point. The values obtained suggest a film profile $d = 11{\cdot}8\times10^{-6}/h^{1/2}$, where d is the actual film thickness in cm at a height h above the liquid level. For the He II film not in direct contact with the liquid, a thickness of 55 atomic layers ($2{\cdot}2\times10^{-6}$ cm) has been observed, independent of temperature and position of the bulk liquid level. This value is discussed in terms of a lack of temperature equilibrium. Observations of the evaporation of the film by radiation influx have been made. The possibility that the disparity between the results of various film determinations may be due to differing conditions of heat influx is considered in the discussion. A.

536.48

1249. A method for the determination of the rate of extension of the helium II film. A. C. Ham and L. C. Jackson. *Phil. Mag.*, **44**, 1403–6 (*Dec.*, 1953).

The optical method of Burge and Jackson [Abstr. 2629 (1951)] was employed to determine the rate of extension of the helium II film over a previously bare solid surface. The passage of the front of the film over two regions of the surface a known distance apart is observed, and a provisional apparatus has shown that the method is feasible and has indicated what changes should be made to obtain significant results. A.

536.48

1250. Helium II film transport rates over machined metal surfaces. B. Smith and H. A. Boorse. Letter in *Phys. Rev.*, **92**, 505 (*Oct.* 15, 1953).

Investigating film transport on "rough" surfaces, the authors use beakers of stainless steel, aluminium, a nickel alloy, silver and copper. The beakers were turned from a cylindrical metal rod, no abrasives or polishes being applied. Observations were made at temperatures between 1·2 and 2·0°K. The authors conclude that the rate of transfer of helium films is a reasonably reproducible quantity even when unpolished surfaces are used and that the numerical values for rough surfaces are not always much higher than on glass surfaces. R. EISENSCHITZ

536.48

1251. The nonparticipation of He^6 in the superfluidity of He^4. L. Guttman and J. R. Arnold. *Phys. Rev.*, **92**, 547–51 (*Nov.* 1, 1953).

In a steady-state experiment, a stream of He^4 containing an extremely small concentration of He^6 has been cooled below the λ-point and passed through a narrow slit as superfluid. If the He^6 atoms had passed through the slit, most of them would have been detected by their radioactive decay in the gas stream leaving the cryostat. The fraction actually

found was $0{\cdot}04 \pm 0{\cdot}07$ (standard deviation) of those expected if there had been no separation of the isotopes. This result is consistent with the Bose–Einstein condensation model for the superfluidity of He^4. A new type of generator for He^6 is described. A.

536.48

1252. Capillarity in helium II. C. T. Lane and R. V. Dyba. Letter in *Phys. Rev.*, **92,** 829 (*Nov.* 1, 1953).

Capillary rise is observed at $2{\cdot}15$ and $1{\cdot}25°K$ in a $36\ \mu$ gap between two glass plates. The level of the bath is, owing to evaporation, lowered in the course of an experiment. The rise of the meniscus beyond the level remains constant, even if the level sinks below the lower edge of one plate, provided that the other plate remains immersed. If, subsequently, the level approaches the triangular end of the second plate, the meniscus breaks down; this takes place when a certain minimum periphery (of 41 and 21 mm length respectively) is offered to the bath.

R. EISENSCHITZ

536.48 : 534.22

1253. First sound in liquid helium at high pressures. K. R. Atkins and R. A. Stasior. *Canad. J. Phys.*, **31,** 1156–64 (*Nov.*, 1953).

The velocity of ordinary sound in liquid helium has been measured in the temperature range from $1{\cdot}2°K$ to $4{\cdot}2°K$ at pressures up to 69 atm. A pulse technique was used with a carrier frequency of 12 Mc/s. Curves are given for the variation of velocity with temperature at constant pressure and also at constant density. There is no detectable discontinuity along the λ-curve. The results are used to discuss the ratio of the specific heats, the coefficient of expansion below $0{\cdot}6°K$ and the specific heat above $3°K$. A.

536.48

1254. The attenuation of second sound above 1°K. K. R. Atkins and K. H. Hart. Letter in *Phys. Rev.*, **92,** 204 (*Oct.* 1, 1953).

Measurements are made in liquid helium between $1{\cdot}1$ and $2{\cdot}1°K$ using heat pulses of $1–2\times10^{-3}$ sec and carrier frequencies of 10, 20 or 30 kc/s. The distance between transmitter and receiver is varied between 4 and 14 cm. Attenuation is derived from the corresponding variation in received intensity; it is found to vary with the transmitted intensity. Attenuation extrapolated to zero intensity is plotted against the temperature. The resulting curve is in accordance with the theory associating dissipation with the emission and absorption of phonons and rotons [Khalatnikov, Abstr. 3258 (1953)]; damping due to ordinary viscosity does not account for the experimental results. R. EISENSCHITZ

536.48

1255. Ultrasonic measurements in liquid helium. C. E. Chase. *Proc. Roy. Soc. A*, **220,** 116–32 (*Oct.* 22, 1953).

Measurements have been made of the velocity and absorption of ordinary sound in liquid helium at frequencies of 2, 6 and 12 Mc/s, over the temperature range from the normal boiling-point down to $0{\cdot}85°K$. The accuracy of the velocity measurements has been increased above that reported in Abstr. 9431 (1951), and the temperature and frequency ranges of those measurements have been extended. Particular attention has been paid to the attenuation in the neighbourhood of the λ-point and in the very low temperature region. The attenuation is found to be very high near the λ-point and at low temperatures, and is proportional to ω^2 between $1{\cdot}2°K$ and the λ-point. At lower temperatures a change in the frequency dependence is observed, indicating the presence of a relaxation effect. The significance of these results is discussed in relation to a recent theory of Khalatnikov. A.

536.483

1256. Metal-to-glass seals for sub-λ point helium apparatus. W. S. Corak and A. Wexler. Note in *Rev. sci. Instrum.*, **24,** 994–5 (*Oct.*, 1953).

Details of copper, zirconium and tungsten to glass seals of tube (ext. dia. $\simeq$ 1 in.) and wire (ext. dia. $\simeq$ 0·025 in.) types are given. These seals were tested by immersion in a liquid helium bath at $1{\cdot}6$ to $1{\cdot}7°K$ and no leaks were found with a leak detector of 5×10^{-9} micro-litre/sec sensitivity. G. WITTENBERG

536.521

1257. The theoretical characteristics of bichromatic pyrometers. H. Herne. *Brit. J. appl. Phys.*, **4,** 374–7 (*Dec.*, 1953).

These are outlined and the response is calculated for different filter pass bands of different band widths. The ratio of the response at one colour to the response at the other is calculated as a function of the temperature of the source and the results are presented graphically. A range of pass bands in the visible spectrum, having sharply defined cut-off frequencies and uniform transmission in the pass frequencies, is considered and the effect of the width of the pass bands is estimated in each case. One result is given for an infrared pyrometer with both pass bands wide and accommodated in the sensitive region of typical lead sulphide photoconductive cells. From these results it is clear that the two pass bands may be close to each other in frequency and that their band widths may be large, without an appreciable loss in sensitivity of the pyrometer. Positive recommendations may then be made that the design of a bichromatic pyrometer should concentrate on energy collection and should therefore adopt two wide pass bands both situated in the red part of the spectrum. A.

536.532

1258. Temperature measurement in a dielectric in a high-frequency field. K. Lamberts. *Abhandl. Braunschw. Wiss. Gesell.*, **5,** 187–98 (1953) *In German.*

Thermocouple measurement in a dielectrically heated work piece is discussed. The influence of the distortion of the electric field by the thermocouple on the heat distribution is calculated and the optimal position of the thermocouple in the field is derived. Examples for the case of wood are in good agreement with the theory. A.

536.58 : 621.316.89 : 621.316.7.077.6

1259. An electronic temperature controller. B. E. Noltingk and M. A. Snelling. *J. sci. Instrum.*, **30,** 349–51 (*Oct.*, 1953).

An instrument is described in which a thermistor, immersed in the fluid system to be controlled, is connected in an a.c. Wheatstone bridge operated at 50 c/s. An error signal results when the thermistor

is not at the required temperature, and is passed, after amplification, to a phase-sensitive detector which operates a relay controlling the heating and/or cooling of the fluid. Special attention is paid to the mounting of the thermistor. Tests have shown that the unit can control a water bath of some 8 gallons capacity within ±0·02°C over a period of weeks. A.

536.581.1 : 621.316.722 : 621.365.4

1260. A graphite tube resistance furnace and voltage regulator for equilibrium studies in the temperature range 1500–1800°C. W. E. Dennis, F. D. Richardson and J. H. Westcott. *J. sci. Instrum.*, **30**, 453–5 (*Dec.*, 1953).

The equilibrium measurements were made in a 1 in. diameter alumina tube, heated by a surrounding graphite tube. The furnace operated at 3–4 V, the power required at temperature being 2½–3 kW. A control unit, which maintained the high-voltage side of a Variac transformer at 200 ± 0·1 V, made it possible to maintain the temperature within ±3°C when half-hourly adjustments of the Variac were made to compensate for changes in the ambient temperature. A.

536.631

1261. The heat capacity of thorium dioxide from 10 to 305°K. The heat capacity anomalies in uranium dioxide and neptunium dioxide. D. W. Osborne and E. F. Westrum, Jr. *J. chem. Phys.*, **21**, 1884–7 (*Oct.*, 1953).

The heat capacity of thorium dioxide was determined in an adiabatic calorimeter. As expected, no anomaly was observed in the heat capacity. The enthalpy, entropy and free energy were calculated from the heat-capacity data and are tabulated for several temperatures. At 298·16°K the entropy and the enthalpy are, respectively, 15·593 ± 0·02 cal deg^{-1} mole^{-1} and 2524·4 ± 3 cal mole^{-1}. By assuming the lattice entropy of uranium dioxide and of neptunium dioxide to be equal to the entropy of thorium dioxide, the magnetic entropy contributions at 298·16°K were evaluated as 3·0 cal deg^{-1} mole^{-1} for uranium dioxide and 3·6 cal deg^{-1} mole^{-1} for neptunium dioxide. These values are somewhat greater than the spin-only values ($R \ln 3 = 2{\cdot}18$ cal deg^{-1} mole^{-1} for uranium dioxide and $R \ln 4 = 2{\cdot}75$ cal deg^{-1} mole^{-1} for neptunium dioxide). The entropies of the other isomorphous actinide dioxides at 298·16°K are estimated to be (in cal deg^{-1} mole^{-1}) 17·8 for PaO_2, 19·7 for PuO_2, 20·0 for AmO_2, 20·3 for CmO_2, 20·6 for BkO_2 and 20·3 for CfO_2. A.

536.631

1262. Specific heat of diamond at low temperatures. R. Berman and J. Poulter. Letter in *J. chem. Phys.*, **21**, 1906–7 (*Oct.*, 1953).

Reports measurements of the enthalpy differences between 4° and 90°K and between 90°K and room temp. Several diamond samples were investigated and the results are compared with those obtained by DeSorbo [Abstr. 5446 (1953)]. E. P. WOHLFARTH

536.631 : 536.48

1263. Atomic heat of indium below 20°K. J. R. Clement and E. H. Quinnell. *Phys. Rev.*, **92**, 258–67 (*Oct.* 15, 1953).

A calorimetric technique in which a carbon-composition resistor serves simultaneously as both heater and thermometer has been developed and is described briefly. Using this technique, the atomic heat of indium has been measured in the normal state from 1·7°K to 21·3°K and in the superconducting state from 1·8°K to 3·396°K, the transition temperature in zero magnetic field. Tables of smoothed values are given. A method of deducing the separate lattice and electronic contributions to the heat capacities, based on several empirically and/or theoretically tenable assumptions, has been developed and is described in some detail. This method of analysis, when applied to the indium data, led to the conclusion that a cubic analytic form for the critical magnetic field equation would allow conclusions consistent with all the assumptions but that the more commonly used parabolic form would not. Numerical values are given for the constants involved. The temperature dependence of the Debye characteristic temperature of the indium lattice over the entire range of measurement is shown to follow the theoretically expected behaviour. A.

536.631 : 548.7

1264. Heat capacity of chain polymeric crystals. W. H. Stockmayer and C. E. Hecht. *J. chem. Phys.*, **21**, 1954–8 (*Nov.*, 1953).

A crude calculation of the frequency spectrum and heat capacity has been made for a simple model of a large crystal composed of long parallel polymer chains. The heat capacity is very unlike that of a cubic crystal but can be represented quite well with a simple two-parameter equation recently proposed by Tarasov. A.

536.631 : 548.7

The vibrational spectrum and specific heat of sodium. *See Abstr.* 1854

536.633

1265. Vapor heat capacities determined by the use of vapor pressure equations. G. M. Barrow. *J. chem. Phys.*, **21**, 1912–13 (*Nov.*, 1953).

Vapour pressure equations have proved useful in providing quantitative data on heats of vaporization but the heat capacity term, occurring in equations of the Rankine type, has been usually treated as an empirical constant. This term represents $Cp^{vap} - Cp^{liq}$ for a vapour obeying the ideal gas laws and it is shown that even for a real gas the same result may be expected to hold. This conclusion is tested for twelve compounds for which data are available. The values of Cp^0 calculated from the heat capacities of the liquid and the difference in heat capacities from the vapour pressure equation are in good agreement with those directly measured and would therefore be of use for thermodynamic calculations. A.

536.633 : 536.44 : 534.22

1266. Specific heat of gases at the critical point. J. F. Lee. Note in *Z. angew. Math. Phys.*, **4**, *No.* 5, 401–4 (1953).

A determinate expression for the sonic velocity at the critical point is derived which permits a direct solution for the constant-volume specific heat as a function of the critical values of T, v, sonic velocity and Joule–Thomson coefficient. Calculated values are compared with zero pressure values for N_2, CO_2 and O_2, the former being two to three times higher.

The significance of the calculated values is discussed in view of the fact that the measured sonic velocity is not the true thermodynamic value. F. E. HOARE

536.66 : 539.132

The heat of sublimation of tin. *See Abstr.* 1518

536.66 : 539.132

Calculation of the heats of formation of gaseous free radical and ions. *See Abstr.* 1519

THERMODYNAMICS 536.7/.8

536.7

1267. On Onsager relations (appendix). J. E. VERSCHAFFELT. *Bull. Acad. Roy. Belgique Cl. Sci.*, **39**, *No.* 2, 165–8 (1953) *In French.*

It is shown that the author's hypothesis of a simple proportionality between each diffusion flux and its conjugate affinity of diffusion is equivalent to that of Prigogine, which admits a linear relation between the flux and the affinity of flow, with equality of the coefficients in the reciprocity relations. F. E. HOARE

536.7

1268. Contribution to the thermodynamics of matter in an electromagnetic field. P. MAZUR AND I. PRIGOGINE. *Mém. Acad. Roy. Belgique Cl. Sci.*, **28**, *No.* 1, 1–56 (1953) *In French.*

This is in three parts dealing with non-polarized systems, non-conducting dielectrics and with polarizable conducting media; in each case non-magnetic media are considered. The method followed in Pt 1 is analogous to that developed previously by Progogine [*Etude thermodynamique des phénomènes irréversible* (1947)] and consists of a systematic study of the different balances necessary for the calculation of entropy production. The entropy production obtained, the conditions of thermodynamic equilibrium are deduced. Two methods of regarding the problem, potential energy attributed to the medium or energy in the local field, are compared. Guggenheim's idea of electrochemical potential is discussed. The nature of the ponderomotive forces is dealt with in Pt 2 and the classical method of Helmholtz developed to show how one can pass from the free energy to the ponderomotive forces. The method followed avoids some difficulties inherent in classical expositions, notably the hypothesis that the dielectric constant is independent of temperature. The conclusions reached are in accord with those of Jouguet obtained by a different method [*Traité d'électricité theorique* (1952)]. An alternative treatment is possible starting with an expression for the ponderomotive force due to Kelvin. From this a general treatment is given. The essential result of this part is to demonstrate the equivalence of the concepts of Helmholtz and Kelvin for reversible changes in dielectrics. Kelvin's concept is used in the third part to calculate the production of entropy and obtain the conditions of thermodynamic equilibrium in a medium which is conducting and polarizable. The conditions permit a thermodynamic justification of the rules proposed by many authors concerning the distribution of matter in a double layer. F. E. HOARE

536.7

1269. Relativistic thermodynamics of irreversible processes. I. Heat conduction, diffusion, viscous flow and chemical reactions; formal part. G. A. KLUITENBERG, S. R. DE GROOT AND P. MAZUR. *Physica*, **19**, 689–704 (*Aug.*, 1953).

The relativistic thermodynamics of irreversible processes is developed for an isotropic mixture in which heat conduction, diffusion, viscous flow, chemical reactions and their cross-phenomena may occur. The four-vectors, representing the relative flows of matter, are defined in such a way that, in the four-dimensional space-time continuum, they are perpendicular to the four-vector which represents the barycentric velocity. The entropy balance is derived from the fundamental relativistic macroscopic laws. If n is the number of chemical components, $n + 4$ relations are found among the $4n + 4$ phenomenological equations obtained for the relative flows of matter and the heat flow. Owing to these relations just that number ($3n$) of independent equations are retained which would be expected from physical considerations. It is shown that the Onsager relations are Lorentz-invariant. A new cross-effect is found between diffusion and heat conduction, arising from a relativistic term in the force conjugate to the heat flow. It appears that due to this cross-effect the diffusion phenomena are influenced by the barycentric motion. A.

536.7

1270. On the thermodynamics of irreversible processes in the case where the temperature and pressure remain constant. K. POPOFF. *C.R. Acad. Sci.* [*Paris*] **237**, 698–700 (*Oct.* 5, 1953) *In French.*

Previous work [Abstr. 3558 (1952); 5435 (1953)] has shown that for irreversible processes in an isolated system the phenomenological relations are the first integrals of a system of differential equations in which the entropy acts as a potential function of the forces. It is now shown that for a system exchanging heat with its surroundings, at constant temperature and pressure, the phenomenological relations are the first integrals of a system of equations. F. E. HOARE

536.7

1271. Themodynamic functions of FCN. N. W. LUFT. Letter in *J. chem. Phys.*, **21**, 1900–1 (*Oct.*, 1953).

The approximate molecular data for FCN reported by Thomas [Abstr. 5951 (1952)] are used for calculating the thermodynamic functions of ideal FCN gas at a pressure of 1 atmos.; these are tabulated for 298·16°, and 300–1000°K at intervals of 100 deg. H. H. HODGSON

536.7

1272. Thermodynamic functions of potassium vapor. M. GRIFFEL. Letter in *J. chem. Phys.*, **21**, 1908 (*Oct.*, 1953).

These are calculated for the monatomic and diatomic species, over 100–3000°K, from spectroscopic data taken from the compilations of Moore, and Herzberg, and physical constants given by DuMond and Cohen. The methods for the rigid-rotator/harmonic-oscillator molecular model, including high-temperature anharmonicity corrections, are used.

The Gibbs and enthalpy functions, the heat capacity, and the dissociation equilibrium constant are tabulated. H. H. HODGSON

536.7 : 519.2

1273. An essentially statistical approach to the thermodynamic problem. M. DUTTA. *Proc. Nat. Inst. Sci. India*, **19**, 109–26 (*March–April*, 1953).

In the entire development, the problem has been discussed macroscopically as a statistical problem of general type. As in phenomenological thermodynamics, no assumption about the structure and the internal mechanism of the system has been introduced. For this, a probability of occurrence of the system, enclosed in a definite volume surrounded by a definite environment, in a state specified by definite values for quantities of matter and energy contained by it, is suitably defined and is taken to be the starting point of the present discussion. The analytical behaviour of the probability, considered as a function of two parameters—the characteristic parameters of distribution—has been investigated and it has been shown that this function has a unique maximum for a set of values of distribution-parameters controlling the energy-exchange and the matter-exchange with the environment. It has been assumed that the state, for which the probability of occurrence is a maximum, corresponds to the observed state, and the values of the distribution-parameters, corresponding to the maximum value of the probability, are taken to specify the state of the system in a definite environment. Thus a probability-distribution of matter and energy has been associated to every observed state of the system. To investigate the effect of variations in the environment of the system, the equation of continuity for energy and matter has been taken in suitable form. Some functions associated with the equation of continuity for energy (the first law of thermodynamics) and that of matter, have been identified as entropy, temperature and the chemical potential of the system. It has also been shown that the method is also suitable for obtaining the laws of microscopic distribution when usual assumptions about microscopic nature of the system are introduced. A.

536.7 : 533.7 : 530.162

Lectures on theoretical physics. Volume 5. Thermodynamics and statistics. *See Abstr.* 1077

536.7 : 537.32

1274. Irreversible thermodynamics of thermoelectric effects in inhomogeneous, anisotropic media. C. A. DOMENICALI. *Phys. Rev.*, **92**, 877–81 (*Nov.* 15, 1953).

Beginning with the isotropic form of the thermoelectric equations of Onsager's irreversible thermodynamics as treated by Callen and deGroot, a direct transcription is made to the case of inhomogeneous and anisotropic media. The "e.m.f." of Kelvin, Bridgman, Ehrenfest and Rutgers is the gradient of the electrochemical potential and a general formula is given for this gradient in anisotropic media. Both the energy density vector and the electrochemical potential gradient are expressed in terms of a "transport entropy matrix" S_{ij}. The theory leads in a natural and straightforward way to the postulated expression of Ehrenfest and Rutgers. The formulation is in a form easily adaptable to given experimental boundary conditions and, therefore, brings out the limited validity of the Kelvin symmetry relations, as first pointed out clearly by Kohler. Finally, the theory includes the irreversible effects of heat conduction and Joulean heating, as well as the reversible thermoelectric phenomena and is, therefore, more realistic and complete than the theory of Ehrenfest and Rutgers. A.

536.71

1275. On a general equation of state of saturated vapours. E. KORDES. Letter in *Naturwissenchaften*, **40**, *No.* 13, 359–60 (1953) *In German.*

Finds that the relation between pressure, volume and temperature for a Van der Waals fluid at the critical point, where the mole volumes of liquid and gas are equal, can be generalized to apply where the liquid and gas volumes are not equal. Gives a table for CO_2, showing good agreement with experiment. L. G. CARPENTER

536.71

1276. On the theory of the virial development of the equation of state of monoatomic gases. R. J. RIDDELL, JR AND G. E. UHLENBECK. *J. chem. Phys.*, **21**, 2056–64 (*Nov.*, 1953).

The problem of the condensation of a gas is intimately related to the asymptotic behaviour of the virial coefficients, B_m, as $m \to \infty$. The problem of the evaluation of the virial coefficients may be divided into two distinctly different ones. The first of these, which is purely combinatorial in nature and is independent of the intermolecular force law, is that of determining the number of a certain type of connected graphs of l points and k lines which are called "stars." This problem is solved by means of generating functions, with the result that the total number of such stars is asymptotically equal to

$$\binom{\frac{1}{2}l(l-1)}{k},$$

for almost all k. Arguments are also presented which indicate that the total number of topologically different stars is

$$\frac{1}{l!}\binom{\frac{1}{2}l(l-1)}{k}.$$

With these results the combinatorial problem is essentially solved. The second problem is that of evaluating certain integrals of functions which depend on the intermolecular potential. This problem is not so near to a solution. For a purely repulsive force, asymptotic expressions are obtained for $k = l$, and $k = l + 1$. The partial contributions to the virial coefficient in these two cases are:

$$(-1)^l \cdot \frac{5}{3}\left(\frac{5}{2\pi}\right)^{\frac{1}{2}}(2b)^{l-1}\frac{(l-1)}{l^{5/2}},$$

and

$$(-1)^l 2 \cdot 5^3 (2b)^{l-1}/24\pi\sqrt{3}),$$

respectively. Results for some simple one-dimensional rigid lines are also given. A.

536.75

1277. On the minimum of entropy production. P. GLANSDORFF. *Physica*, **19**, 737–41 (*Aug.*, 1953) *In French.*

The conditions for minimum entropy production in

a continuous medium with given boundary conditions are derived without using any kinetic hypothesis. The treatment is applicable to any extensive quantity.

R. O. DAVIES

ELECTRICITY 537

THEORY . ELECTRONS 537.1

537.12 : 530.162 : 539.11

1278. A collective description of electron interactions. III. Coulomb interactions in a degenerate electron gas. D. Bohm and D. Pines. *Phys. Rev.*, **92**, 609–25 (*Nov.* 1, 1953).

For Pt II, see Abstr. 2688 (1952). The behaviour of the electrons in a dense electron gas is analysed quantum-mechanically by a series of canonical transformations. The usual Hamiltonian corresponding to a system of individual electrons with Coulomb interactions is first re-expressed in such a way that the long-range part of the Coulomb interactions between the electrons is described in terms of collective fields, representing organized "plasma" oscillation of the system as a whole. The Hamiltonian then describes these collective fields plus a set of individual electrons which interact with the collective fields and with one another via short-range screened Coulomb interactions. There is, in addition, a set of subsidiary conditions on the system wave function which relate the field and particle variables. The field–particle interaction is eliminated to a high degree of approximation by a further canonical transformation to a new representation in which the Hamiltonian describes independent collective fields, with n' degrees of freedom, plus the system of electrons interacting via screened Coulomb forces with a range of the order of the interelectronic distance. The new subsidiary conditions act only on the electronic wave functions; they strongly inhibit long wavelength electronic density fluctuations and act to reduce the number of individual electronic degrees of freedom by n'. The general properties of this system are discussed, and the methods and results obtained are related to the classical density fluctuation approach and Tomonaga's one-dimensional treatment of the degenerate Fermi gas.

A.

537.12 : 530.162 : 539.11

1279. A collective description of electron interactions. IV. Electron interaction in metals. D. Pines. *Phys. Rev.*, **92**, 626–36 (*Nov.* 1, 1953).

The effects of the Coulomb interaction between free electrons in an electron gas are considered for a variety of phenomena. The analysis is based on the collective description, which describes the long-range correlations in electronic positions (due to the Coulomb force) in terms of the collective oscillations of the system as a whole. It is shown that an independent electron model should provide a good description of the electrons in a metal in many cases of interest. The ground state energy of the free electron gas is determined, and an estimate of the correlation energy is obtained, with results in good agreement with those of Wigner. The exchange energy is shown to be greatly reduced by the long-range correlations, so that its effect on the level density and the specific heat is comparatively slight, leading to an electronic specific heat for Na which is approximately 80% of the free electron value. The possible ferromagnetism of a free electron gas is investigated, and it is found that the long-range Coulomb correlations are such that a free-electron gas will never become ferromagnetic (no matter how low the density). The excitation of the collective oscillations by a fast charged particle is studied, and the semi-classical results obtained by Bohm and Pines are verified by a quantum-mechanical calculation. The results are applied to the experiments of Ruthermann and Lang on the scattering of electrons by thin metallic films and to experiments on the stopping power of light metals for fast charged particles, with resulting good agreement between theory and experiment. A.

ELECTROSTATICS . DIELECTRICS 537.2

537.221 : 621.319.7

1280. Contact electrification. P. S. H. Henry. *Sci. Progr.*, **41**, 617–34 (*Oct.*, 1953).

A review. Points discussed include the polarities and magnitudes of the charges generated and the theories advanced to account for the phenomenon. The effects of "static" in industry and methods of overcoming it are described.

A. E. KAY (R)

537.222

1281. Lower bounds for the electrostatic capacity of a cube. J. McMahon. *Proc. Roy. Irish Acad. A*, **55**, *No.* 9, 133–67 (*July*, 1953).

The method of pyramid function used by J. L. Synge for plane problems is generalized to three dimensions and used to get a lower bound to demonstate the application of pyramid vector fields of the second class to boundary value problems. To the order of approximation worked out $0{\cdot}639273a < C$.

A. E. KAY

537.224 : 530.162

1282. A random walk related to the capacitance of the circular plate condenser. E. Reich. *Quart. appl. Math.*, **11**, 341–5 (*Oct.*, 1953).

It is shown that the solution of Love's equation [Abstr. 4051 (1950)] for the capacitance of the circular plate condenser can be expressed in terms of the mean duration of a certain one-dimensional random walk with absorbing barriers. The interpretation as a random walk makes it possible to confirm the fact that the actual capacitance of the condenser is always larger than the value given by the standard approximation for small separations, and yields an upper bound as well. In addition to its theoretical interest, the random walk appears to provide a practical means for the calculation of the capacitance by a Monte Carlo technique.

A.

537.226

1283. The properties of colloidal ferroelectrics. II. Theoretical considerations. W. KÄNZIG AND R. SOMMERHALDER. *Helv. phys. Acta*, **26**, *No.* 6, 603–10 (1953) *In German.*

In Pt I, Abstr. 8387 (1953) experiments were described, which showed that a critical crystal diameter exists, below which an insulated ferroelectric KH_2PO_4-crystal cannot polarize spontaneously. Pt II shows that this effect can be understood, if the energy of the depolarizing field and the energy of the domain walls is introduced into the free energy of the crystal given by the Mueller theory. The interaction of a polarized ferroelectric crystal with its depolarizing field is discussed. An exact solution of the problem is possible for the spherical single domain crystal. For multi-domain crystals an ε^*-correction (analogous to the μ^*-correction for ferromagnetics) has to be introduced, which, however, loses its validity for small domain numbers. A discussion of the wall problem is given. Theoretically, a wall thickness of about one lattice spacing has to be expected. For a dipolar wall the surface energy density should be αP^2, where α is of the order of magnitude of the lattice spacing. An experimental estimate of α can be given, using the critical crystal diameter reported in the Pt I, giving $\alpha \simeq 21 \cdot 10^{-8}$ cm. This value appears to be consistent with the assumption of classical dipole-dipole interaction and of a wall thickness of a few lattice spacings. A.

537.226.2

1284. Dielectric properties of salt solutions in the range of ultra-high frequencies (230–330 Mc/s). R. SANKARAN AND S. R. KHASTGIR. *J. sci. Res. Banaras Hindu Univ.*, **2**, 101–12 (1951–52).

Using a Lecher wire system with a condenser filled with the solutions, the width of the resonance curve was found as a function of concentration. There are maxima, e.g. at 0·15380N for NaCl and 0·13410N for KCl at 326 Mc/s. For NaCl, KCl, $MgCl_2$ and $CuSO_4$ the results are in broad agreement with the ionic atmosphere relaxation theory of Falkenhagen [*Electrolytes* (1934)]. D. H. WHIFFEN

537.226.2

1285. Ferroelectricity versus antiferroelectricity in the solid solutions of $PbZrO_3$ and $PbTiO_3$. E. SAWAGUCHI. *J. Phys. Soc. Japan*, **8**, 615–29 (*Sept.–Oct.*, 1953).

The phase diagram of the solid solutions of the $PbZrO_3$–$PbTiO_3$ system has been established by investigating dielectric, dilatometric, calorimetric and structural properties. In $Pb(Zr97–Ti3)O_3$ four kinds of polymorphic modification have been found, that is, successively, the antiferroelectric, the other antiferroelectric, the ferroelectric and the paraelectric phases. By making use of the phase diagram and of the forced transition which causes a phase change from an antiferroelectric phase to the ferroelectric, owing to an intense electric field influence, the free energies of these four states have been compared with one another as functions of temperature and the concentration of the solid solution. It is found that the antiferroelectric phase near the Curie point 230°C in pure $PbZrO_3$ is more stable than the ferroelectric one by only about 4 cal/mole; and with increasing concentration of $PbTiO_3$ the free energy of the ferroelectric phase decreases gradually at an initial rate of 0·5 cal/mole/atomic per cent. At the same time the two antiferroelectric phases lose their stability at the rates 5·8 cal/mole/atomic per cent and 2·3 cal/mole/atomic per cent respectively. The atomic arrangement in the ferroelectric $Pb(Zr58–Ti42)O_3$ has been examined. The sample of this concentration has the rhombohedral structure C_{3v}^5–$R3m$: The displacement of Pb atom relative to Zr or Ti atom is about 0·14 kX along the [111] direction. A.

537.226.2

1286. Low-temperature dielectric properties of cadmium and lead niobates. J. K. HULM. Letter in *Phys. Rev.*, **92**, 504 (*Oct.* 15, 1953)

The upper Curie point for $Cd_2Nb_2O_7$ is about 187 to 183°K and falls slightly for higher firing temperatures during preparation. A small anomaly in dielectric constant at 80°K marks a phase change. Measurements down to 1·2°K suggest that $Pb_2Nb_2O_7$ is probably not ferroelectric. C. A. HOGARTH

537.226.2

1287. The conductivity of germanium at $2{\cdot}4 \times 10^{10}$ cps. Y. KLINGER. Letter in *Phys. Rev.*, **92**, 509 (*Oct.* 15, 1953).

Measurements of permittivity and loss tangent on a highly purified single crystal of Ge (d.c. resistivity at room temperature 56 ohm cm) over the range 0–100°C. The results indicate an activation energy of 0·775 eV for d.c. and 0·60 eV at 1·24 cm. The conductivities for d.c. and at 1·24 cm are approximately in the ratio 2 : 1 at 100°C. The derived conductivities and permittivities are discussed in relation to Kronig's formulae [*Proc. Roy. Soc.*, **133**, 255 (1931)]. A. E. DE BARR

537.226.2

1288. Dielectric properties and phase transitions of $Cd_2Nb_2O_7$ and $Pb_2Nb_2O_7$. G. SHIRANE AND R. PEPINSKY. Letter in *Phys. Rev.*, **92**, 504 (*Oct.* 15, 1953).

The dielectric constant ε of $Cd_2Nb_2O_7$ has a peak value of 1200 at the Curie temperature which lies between 182 and 188°K. There is a further small anomaly at 85°K. Well-defined ferroelectric hysteresis loops are found from 185 to 4°K. For $Pb_2Nb_2O_7$ the value of ε varies from 185 at room temperature to 360 at 14°K and to 353 at 4°K. It is doubted if this material is a ferroelectric. For mixed systems $(Cd, Pb)_2Nb_2O_7$ the Curie temperature decreases with increasing Pb concentration. C. A. HOGARTH

537.226.2

1289. Dielectric properties of hydrogen halides. I. Hydrogen bromide. N. L. BROWN AND R. H. COLE. *J. chem. Phys.*, **21**, 1920–6 (*Nov.*, 1953).

Static dielectric constants of solid hydrogen bromide have been measured from 186 to 70°K, and dispersion and loss below 89°K in the frequency range 15 c/s to 5 Mc/s. Special cell designs minimized formation of cracks and voids in the polycrystalline sample, as such flaws were shown by several lines of evidence to cause serious errors. Static dielectric constants above 117°K are in quite good agreement

with Onsager's equation. In phase II, stable below 113°K, the dielectric constant rises to a peak of 200 at 89°K, then falls to a value of 32 at 70°K in phase III. The principal dispersion below 89°K follows a circular arc locus with $\alpha = 0{\cdot}3$, and a rate expression with activation energy 2·7 kcal/mole. A second dispersion is observed at much higher frequencies with energy 1·59 kcal/mole, and it is suggested that the two dispersions are a consequence of crystal anisotropy. A.

537.226.2 : 538.22 : 535.341–14

1290. An optical method for the measurement of dielectric and magnetic constants at centimetre and millimetre wavelengths. J. Benoit and T. E. Talpey. *Nuovo Cimento*, **9**, *Suppl. No.* 3, 231–7 (1952) *In French.*

The real parts are obtained from the Brewster angle and the reflection coefficient at a plane interface for $\perp$ polarized waves, and the losses from the total transmission and the ratio of the reflection coefficients for $\perp$ and $\parallel$ polarized waves. The theory, including corrections for multiple reflections with thin sheets, is given, and also photographs of the apparatus and the results for Bakelite, glass, paraffin and polystyrene. D. H. WHIFFEN

537.226.2 : 539.132

1291. Dielectric polarization and structure of polar liquids under pressure. F. E. Harris, E. W. Haycock and B. J. Alder. *J. chem. Phys.*, **21**, 1943–8 (*Nov.*, 1953).

The static dielectric constants of n-butyl alcohol, t-butyl alcohol, n-butyl chloride, n-butyl bromide, t-butyl chloride and water were experimentally determined over a temperature range of 14° to 50°C and over a pressure range of 1 to 200 atmos. In addition, for glycerol, both the static dielectric constant from −18° to 14°C and the dielectric relaxation data at 0°C and up to 1·5 Mc/s were obtained over the same pressure interval. The theory of dielectric polarization was then applied to these measurements to determine the molecular interaction. On the basis of the molecular interaction, structures and structure changes with temperature and pressure have been proposed for the various liquids studied. A.

537.226.8

1292. Nucleation in a dielectric. V. Daniel and C. Turner. *Phil. Mag.*, **44**, 1371–91 (*Dec.*, 1953). Based on *Rep. Brit. Elect. Res. Assoc.* L/T 291 (1953).

Nucleation from solid solution is investigated by means of dielectric measurements. The material investigated is a crystalline mixture of "equivalent" ketones, a system analogous to a mixture of isotopes which tends to segregate. During successive stages of nucleation within an unstable solid solution, dielectric constants and loss angles increase and pass through maxima. Early stages of nucleation represent short-range ordering and are structure-insensitive, while later stages represent long-range ordering and are comparatively structure-sensitive. A.

537.226.8 : 621.318.57 : 621.316.549

1293. The effect of humidity variation on the operation of an electronic proximity switch. R. A. K. Long. *J. sci. Instrum.*, **30**, 422–4 (*Nov.*, 1953).

A survey of information on the effect of humidity variation on the capacitance of air gap condensers shows that the reason for departure from the theoretical variation is not fully understood. The effect on a laboratory and industrial control instrument, which utilizes the capacitance of an electrode to earth, is determined, and precautions to ensure stability are recommended. A.

ELECTRIC CONDUCTION . CURRENTS 537.3

537.311.31 : 536.48 : 536.212.2

The thermal and electrical conductivity of magnesium at low temperatures. *See Abstr.* 1236

537.311.31 : 537.32

1294. The additional electrical resistance and thermoelectric power due to vacancies in metals. F. Abelès. *C.R. Acad. Sci.* [*Paris*] **237**, 796–8 (*Oct.* 12, 1953) *In French.*

A theoretical estimate is obtained by calculating the effective cross-section of a vacancy, represented by an equivalent repulsive potential, for scattering of electrons. The exact results are compared with those obtained in Born's approximation. E. H. Sondheimer

537.311.33

1295. Electrical resistance measurements on heterogeneous polyphase mixtures. E. Plötze, A. Rubin and A. Zwetsch. Note in *Naturwissenschaften*, **40**, *No.* 15, 408–9 (1953) *In German.*

Results are given of measurements of the specific resistance of water-silicate systems pressed into pastille form, the water content varying from 0·7% to 6·1%. Reference is made to the mechanism of conductivity in such systems, which are of interest in the ceramic industry. The resistivity is plotted as a function of density which varies from 0·8 to 2·2 g/cm^3, and the curves show minima in the neighbourhood of a density of 1·5. M. R. Hopkins

537.311.33

1296. The electrical behaviour of AlSb. E. Justi and G. Lautz. *Abhandl. Braunschw. Wiss. Gesell.*, **5**, 36–47 (1953) *In German.*

In previous papers [Abstr. 5111 (1952); 3306, 1638 (1953)] the authors have reported on the semiconducting character of CdSb. The present measurements confirm the semiconducting mechanism of AlSb also, in the extrinsic range near room temperature, i.e. a decrease of resistivity with increasing temperature. The accuracy of these measurements and the purity of the AlSb samples makes it possible to find below the intrinsic range two other activation energies of 0·53 and 0·08 eV, which were unknown hitherto. The positive sign of the thermoelectric force and of the rectifying curve prove that AlSb is a *p*-type conductor; perhaps the hole conduction is caused in analogy to CdSb by an impurity content of 0·01% Pb in the purest Sb samples now available. Rectifying characteristics are measured for both low and high resistivity specimens, depending on different hole concentration. The maximal rectifying ratio obtained is greater than 1 : 10^4. Specimens with high back voltages show small forward currents and vice versa. The metallurgical process and the corrosion of AlSb

samples observed but not overcome by Tammann and Rühenbeck are discussed in detail. A.

537.311.33

1297. On the thermal conversion of germanium. F. VAN DER MAESEN, P. PENNING AND A. VAN WIERINGEN. *Philips Res. Rep.*, **8**, 241–4 (*Aug.*, 1953).

Experiments were carried out regarding the conversion of *n*-type germanium into *p*-type by heat treatment at 800°C. The results indicate that the conversion is due to the presence of acceptor impurities on the Ge surface prior to heating. As long as the surface is clean its roughness seems to have no influence on the conversion. Experiments with pieces of Ge saturated with Cu at 800°C show that the Cu is distributed all over the sample in some form after being inactivated by heat treatment at 500°C. An effect of Ni was found. A.

537.311.33

1298. A simultaneous study of the conductivity and flicker effect in thin films and in crystal detectors. N. NIFONTOFF. *J. Phys. Radium*, **14**, 42 S–44 S (*Oct.*, 1953) *In French.*

Measurements of flicker effects on very thin C films, which do not obey Ohm's Law, show that the spectral density is given by $\log \overline{e_r^2} = f(\log I)$ instead of the normal $\overline{e_r^2} = KI^2$. The author stresses the analogy between the curves $3 \log Rd = f(\log I)$ and $y = \log \overline{e_r^2} - 2 \log I$ where $Rd = dV/dI$ = dynamic resistance. Very similar behaviour was observed with Ge rectifiers. A. H. W. BECK

537.311.33

1299. Surface recombination in germanium. W. N. REYNOLDS. Letter in *Proc. Phys. Soc.* [*London*] *B*, **66**, 899–901 (*Oct.*, 1953).

Measurements of the Suhl effect on *n*- and *p*-type germanium in the range 90 to 350°K. The diminution of surface recombination velocity s with increasing temperature suggests that carriers are first trapped at the surface and s increases with the time spent in traps. C. A. HOGARTH

537.311.33

1300. On the electric conductivity of cuprous sulphide; experiment. S.-Y. MIYATANI AND Y. SUZUKI. Note in *J. Phys. Soc. Japan*, **8**, 680–1 (*Oct.*, 1953).

β–Cu_2S shows both ionic and electronic conductivity. Experiments on the variation of current with time for a given applied voltage enable the mobility and concentration of lattice defects [excess Cu^+ ions] to be calculated. C. A. HOGARTH

537.311.33

1301. New etches for germanium. R. C. ELLIS, JR AND S. P. WOLSKY. Letter in *J. appl. Phys.*, **24**, 1411–12 (*Nov.*, 1953).

Etching solutions for Ge, prepared from various organic and inorganic materials to replace HF, gave favourable electrical characteristics compared with those produced by the usual etches containing HF. J. FRANKS

537.311.33

1302. The electrical properties of black phosphorus. R. W. KEYES. *Phys. Rev.*, **92**, 580–4 (*Nov.* 1, 1953).

The electrical conductivity of black phosphorus has been measured as a function of temperature and pressure up to 350°C and 8000 kg/cm². The Hall constant of the same material has been measured as a function of temperature at atmospheric pressure. At low temperatures *p*-type impurity conduction is observed; at high temperatures the phosphorus is an intrinsic semiconductor with a gap width of 0·33 eV. The mobilities at 27°C are 350 cm²/volt sec and 220 cm²/volt sec for the holes and electrons, respectively. Application of hydrostatic pressure decreases the gap at a rate $VdW/dV = 8 \cdot 3$ eV. The results are also interpreted in terms of a two-dimensional semiconductor model. A.

537.311.33

1303. On conduction in impurity bands. W. BALTENSPERGER. *Phil. Mag.*, **44**, 1355–63 (*Dec.*, 1953).

The idea of conduction by electrons in the energy bands of an impurity system is examined. For a lattice of hydrogen-like impurities the edges of the 1*s*, 2*s* and 2*p* bands are calculated. Effective masses for electrons in these bands are introduced. With their help measurements of the conductivity and the Hall constant are interpreted. Depending on the density of the impurities and on the temperature, conduction takes place predominantly either in the band of the medium, or in excited impurity states, or in the 1*s* impurity band. In this last case the activation energy vanishes. This interpretation implies a description of the electronic state of the impurities with band wavefunctions and indicates the validity of such a description up to rather large values of the lattice constant. This can, however, be reconciled with the insulating properties of the oxides of transition metals. A.

537.311.33 : 535.343.2–15

1304. Infrared absorption of *p*-type germanium. W. KAISER, R. C. COLLINS AND H. Y. FAN. Note in *Naturwissenschaften*, **40**, *No.* 18, 479 (1953) *In German.*

The infrared absorption spectrum of *p*-type Ge (In or Al being used as acceptors) has been found to be more complex than that of the *n*-type Ge. The absorption constant, as evaluated from the Hall effect measurements, is proportional to the carrier density n. Details of the absorption bands and results of measurements at low temperatures are described. F. LACHMAN

537.311.33 : 536.212.2

1305. Electronic thermal conduction in superconductors. P. G. KLEMENS. Note in *Proc. Phys. Soc.* [*London*] *B*, **66**, 576–7 (*June*, 1953).

It is assumed that in a superconductor with temperature gradient there is an internal circulation consisting of a supercurrent J_s and a normal current $J_n = -J_s$. J_n is given by the usual expression for a current set up by a temperature gradient and electric field F, but the latter is assumed to be zero. It is shown that the additional heat transport due to the internal circulation is only a small fraction $\simeq kT_c/\zeta$ of the normal heat conduction (T_c = critical temp., ζ = Fermi energy). H. LONDON

537.311.33 : 537.323

1306. Measurement of the thermoelectric power of germanium at temperatures above 78°K. A. E. MIDDLETON AND W. W. SCANLON. *Phys. Rev.*, **92**, 219–26 (*Oct.* 15, 1953).

A systematic investigation has been made in the range between 78°K and about 925°K. The general method of measurement is the determination, through

thermocouple readings, of the ratio $\Delta E/\Delta T$, where ΔE is the thermal e.m.f. (relative to chromel) measured between two points in the sample having a temperature difference ΔT. At first, difficulty was experienced in obtaining reliable and reproducible thermoelectric power data at the lower temperatures (78°K to about 350°K). A detailed discussion is given of the steps taken to eliminate this difficulty by reducing or removing the effects of thermal conduction by the thermocouple wires, convection currents around the sample, poor contacts between thermocouple junctions and the sample, and inhomogeneities in the thermocouple wires. In the impurity range the sign of the thermoelectric power is the sign of the Hall coefficient, and the magnitudes of thermoelectric power, resistivity and Hall coefficient increase with decreasing impurity content. With rising temperature the thermoelectric power increases in magnitude and passes through an extremum at a temperature somewhat lower than that corresponding to the end of the exhaustion range or flat portion of the Hall curve. The thermoelectric power of a *p*-type sample passes through zero at a temperature higher than that at which the Hall coefficient of the same sample becomes zero. The thermoelectric power curves of both *p*-type and *n*-type samples approach a common curve, having negative values, in the intrinsic range. A.

537.311.33 : 537.323

1307. Theory of thermoelectric power in semiconductors with applications to germanium. V. A. Johnson and K. Lark-Horovitz. *Phys. Rev.*, **92**, 226–32 (*Oct.* 15, 1953).

The thermoelectric power Q of a semiconductor is found by calculating the Thomson coefficient σ_T from electrical and thermal current density expressions and then integrating the relation $\sigma_T = TdQ/dT$. This procedure yields a general expression for Q in terms of the Fermi level, forbidden band width, temperature ratio of electron to hole mobility and effective electron and hole masses. In the impurity range the general formula for Q reduces to a simple dependence on the Hall coefficient and temperature if carrier scattering is largely due to the lattice of the semiconductor; the same expression may be used with the addition of a correction term when carrier scattering by impurity ions becomes important at the lower temperatures. When both holes and electrons must be considered as carriers, Q can be evaluated at any temperature from the resistivity and Hall coefficient at that temperature. An expression is also obtained for the thermoelectric power of an intrinsic semiconductor in a form depending on the mobility ratio, forbidden band width at 0°K and the temperature rate of change of this band width. Hall and resistivity data measured for six polycrystalline germanium samples and two silicon samples have been inserted into the theoretical expressions derived in this paper. The thermoelectric power curves so calculated are found to give generally good agreement with the measured curves. A.

537.311.33 : 537.323

1308. Thermoelectric power of germanium below room temperature. H. P. R. Frederikse. *Phys. Rev.*, **92**, 248–52 (*Oct.* 15, 1953).

The thermoelectric power of germanium single crystals has been measured in the temperature range 10 to 300°K. *N*-type samples of various impurity content have been investigated. Results show that the thermoelectric power Q decreases with increasing concentration of carriers. A few values of the heat conductivity are also reported. The conventional theory predicts a relation between the thermal e.m.f. and the Hall coefficient. The temperature dependence of the thermoelectric power is in good agreement with this relation at temperatures higher than 200°K. Below this temperature Q rises sharply above the value given by this expression, reaches a maximum of several millivolts per degree near 15°K and decreases again at lower temperatures. Large deviations may be expected at low temperatures due to the disturbance of the phonon equilibrium. The phonon current has a strong influence on the interaction with electrons and may lead to a maximum in the thermoelectric power at low temperatures. The contribution due to the non-equilibrium of the lattice is proportional to the ratio of phonon and electron mean free path. The former is related to the thermal conductivity while the latter can be derived from electrical data. A.

537.311.33 : 537.534.8

A study of secondary emission of electrons from impurity semiconductors. *See Abstr.* 1406

537.311.33 : 621.3.011.22 : 621.315.592

1309. Aggregates of some semiconductors showing nonlinear resistance. S. Teszner, P. Seguin and J. Millet. *Ann. Télécomm.*, **8**, 271–98 (*Aug.–Sept.*, 1953) *In French.*

The aggregates consist of mainly silicon carbide which is bound with clays of different compositions. Elementary ideas on the properties of conductors and semiconductors are discussed in terms of the departure of the voltage/current characteristic from Ohm's law. The methods by which the aggregates are prepared, and their compositions, are discussed in terms of their experimentally revealed electrical properties. A theoretical interpretation attempted suggests further lines of research. In particular it is thought that the binding material may profoundly modify the electrical characteristics of the aggregate. Applications are surveyed. W. BARDSLEY

537.311.33

1310. Studies of volume rectification in certain polar crystals. S. R. Khastgir and S. K. R. Tolpadi. *J. sci. Res. Banaras Hindu Univ.*, **1**, 38–59 (*July*, 1950–51).

537.311.33

1311. Recovery currents in germanium *p–n* junction diodes. R. G. Shulman and M. E. McMahon. *J. appl. Phys.*, **24**, 1267–72 (*Oct.*, 1953).

When a germanium *p–n* junction biased in the forward direction has a reverse voltage suddenly applied, a large transient current flows during the "recovery time." A proposed mechanism for this current involving diffusion of stored minority carriers to the barrier is compared with experimental results. Since the current is related to the diode forward direction characteristics these are examined. Finally a variable time delay utilizing the recovery current effect is discussed. A.

537.311.33

1312. Thermal effects at point contact diodes. P. M. Tipple and H. K. Henisch. *Proc. Phys. Soc.* [*London*] *B*, **66**, 826–32 (*Oct.*, 1953).

A thermoelectric method is described which enables the temperature of a point contact to be determined. Measurements have been made on a germanium diode at various positions on the voltage–current characteristic and it is found that voltage turnover occurs at a critical contact temperature, which is constant for a given specimen. The result also shows that temperature gradients in the neighbourhood of a hot point contact can increase the contact resistance. An interpretation of this observation is proposed. A.

537.311.33

1313. Theory of the forward characteristic of injecting point contacts. P. C. Banbury. *Proc. Phys. Soc.* [*London*] *B*, **66**, 833–40 (*Oct.*, 1953).

The voltage–current relationship for forward voltages across a metal–semiconductor point contact is derived for the case when the current is carried by injected minority carriers. The analysis is made with the assumption of unit injection ratio, and neglecting recombination. The effect of departures from these approximations is discussed briefly, and the predictions are compared with the well-known features of observed characteristics, and with some photoconductive and photovoltaic measurements. A.

537.311.33

1314. Forward characteristic of injecting area contacts on germanium. H. K. Henisch and F. D. Morten. *Proc. Phys. Soc.* [*London*] *B*, **66**, 841–4 (*Oct.*, 1953).

A method is described whereby the voltage–current relation of the barrier associated with an injecting area contact on germanium can be investigated. The method involves capacitance measurements in the presence of injected minority carriers. The effect of the series resistance is eliminated. The results show good agreement with theory. A.

537.311.33

1315. A study of carrier injecting properties of emitter contacts and light spots at normal and moderately elevated temperatures. C. A. Hogarth. *Proc. Phys. Soc.* [*London*] *B*, **66**, 845–58 (*Oct.*, 1953).

The method of determining the injection efficiency γ of an emitter contact is discussed and some of the difficulties of the method and the interpretation of experimental results are described. The effects of a fine spot of white light when used as an emitter and hence as a conductivity modulator are investigated and an equivalent minority carrier current for a given optical assembly can be determined. This procedure suggests an experimental method for the determination of γ as a function of temperature. A simple theory for γ in terms of forbidden energy gap, depth of Fermi level, and barrier height ϕ is given and applied to the determination of barrier heights at room temperature, at elevated temperatures, and when an emitter contact on germanium is illuminated. Theoretical curves relating γ and ϕ are presented for Ge and Si of various impurity concentrations. The experiments carried out at elevated temperatures suggest that the surface states on germanium lie at the top of the filled band and that their density is of order 10^{10}–10^{11} cm^{-2}. A.

537.311.33

1316. On the diffusion of decaying particles in a radial electric field. J. Keilson. *J. appl. Phys.*, **24**, 1397–1400 (*Nov.*, 1953).

The diffusion of charged particles in the presence of a radial inverse-square electric field is difficult to treat in any general manner. It is possible, however, to treat steady-state radially symmetric flow in such a field. There may then be deduced, from the radial distributions obtained, a function, γ, which provides an important description of steady-state flow from a point source in the radial field. The important point is made that the function γ obeys the differential equation adjoint to that describing time-independent diffusion in the given field. The physical problem treated is of specific interest to transistor theory, but it is hoped that some of the techniques used in treating the problem are of more general interest. A.

537.311.33 : 537.583 : 621.38

1317. The influence of impurity atoms on flicker noise. Y. Inuishi and T.-C. Yang. Note in *J. Phys. Soc. Japan*, **8**, 565–7 (*July–Aug.*, 1953).

Assuming that "contact noise" whether in barrier layers, carbon resistors, or vacuum tubes (flicker noise), arises from a common cause, i.e. is generated through modulation of the electron current by the density fluctuation of some external fluctuating agent at interfaces, a generalized theory for the mean square noise current is outlined. Comparison with experiments on oxide-coated cathodes shows fair agreement.

C. A. Hogarth (R)

537.311.33 : 621.317.34 : 621.314.63

1318. Measurements of noise spectra of a point contact germanium rectifier. F. J. Hyde. *Proc. Phys. Soc.* [*London*] *B*, **66**, 1017–24 (*Dec.*, 1953).

Measurements have been made of the excess noise produced by a point-contact germanium rectifier in the frequency range 0·117 c/s to 14 Mc/s at 29·5°C, with the reverse direct current I as parameter. The experimental noise spectral density is shown to consist of three well-defined types of component: (*a*) a basic component $\propto f^{-1}$ detectable over as many as 7 decades of frequency; (*b*) two components $\propto [1 + (2\pi f\tau)^2]^{-1}$ associated with single relaxation times $\tau = \tau_1$ and τ_2; (*c*) a uniform component detectable at high frequencies. There is no simple dependence of these densities on current, except that the uniform component is equal to shot noise for small currents. τ_1 and τ_2 are found to be dependent on I. A.

537.311.33 : 621.314.7 : 621.375.4

1319. Transient response of the grounded base transistor amplifier with small load impedance. J. S. Schaffner and J. J. Suran. *J. appl. Phys.*, **24**, 1355–7 (*Nov.*, 1953).

An analysis of the transient response of transistor amplifiers necessitates the consideration of transit time effects. Transit time behaviour of minority carriers is described by the diffusion equation. Since the diffusion equation applies to minority carriers in the base region of a transistor, a current transfer function may be derived, from the diffusion equation, relating the collector current to the emitter current.

This transfer function is valid only when the transistor is operated as a linear amplifier with small load impedance. For these conditions, the transfer function is solved for the collector current response to a step in emitter current by use of Laplace transform techniques. The collector current rise time, as a function of the α-cut-off frequency, is derived from the theoretical equations and compared to measured values. A.

537.311.4

1320. The properties of carbon contacts. R. O. GRISDALE. *J. appl. Phys.*, **24**, 1288–96 (*Oct.*, 1953).

Microphone carbon has been produced by deposition of pyrolytic carbon films over the surfaces of small spherules of silica. The properties of contacts between these spherules are shown to be dependent on the structure and geometry of the carbon surface as determined by electron diffraction and microscopic studies. The graphite-like crystallites in pyrolytic carbon surfaces are more or less preferentially oriented with their basal planes parallel to the surface, and the contact properties depend systematically on the degree of orientation. This is explained in terms of the anisotropy in properties of these crystallites which are closely approximated by those of single crystal graphite which were determined. The contact resistance and its temperature coefficient and the "burning voltage" for carbon contacts are explicable on this basis. However, the microphonic sensitivity of carbon contacts is independent of the surface structure and depends only on the surface geometry. A.

537.311.62 : 535.137

1321. The anomalous skin effect and the reflectivity of metals. III. General theory of low-frequency and optical behaviour. R. B. DINGLE. *Physica*, **19**, 729–36 (*Aug.*, 1953).

For Pt II, see Abstr. 6788 (1953). A general method is devised for solving the integro-differential equation of the anomalous skin effect in the low-frequency and optical regions, and formulae derived for the optical constants of metals on the assumption that a known fraction of the electrons is reflected specularly at the internal surface. A.

537.312 : 537.534.9

1322. Change of electrical conductivity of sodium chloride upon bombardment with high-energy protons. E. A. PEARLSTEIN. *Phys. Rev.*, **92**, 881–2 (*Nov.* 15, 1953).

The conductivity of NaCl in the region 125°C to 400°C is considerably decreased by bombardment at room temperature with 10^{15} protons/cm^2 of energy 350 MeV. There are several temperatures where part of the effect anneals. A small decrease in conductivity still remains after heating to as high as 470°C. No satisfactory explanation for the results is evident. A new method of measuring conductivity is described. A.

537.312.5

1323. On the interpretation of experiments on photoconductivity in high fields. D. CURIE. *C.R. Acad. Sci.* [*Paris*] **237**, 791–4 (*Oct.* 12, 1953) *In French.*

Recent observations [e.g. Abstr. 7194 (1952)] of photoelectric currents in luminescent ZnS powder, irradiated at 3660 Å, which exceed by a factor 1000 the current to be expected from unit quantum efficiency, are tentatively explained by an electron multiplication process within the phosphor. The multiplication is due to ionization of shallow (~ 1 eV) donor levels by conduction electrons in fields of 10^4 V/cm or higher. F. ANSBACHER

537.312.5

1324. Photo-electric multipliers. S. RODDA. *London: Macdonald*, 180 *pp.*

Review in *J. sci. Instrum.*, **30**, 437 (*Nov.*, 1953).

537.312.5

1325. Photoelectric studies of iron. A. B. CARDWELL. *Phys. Rev.*, **92**, 554–6 (*Nov.* 1, 1953).

Studies of the photoelectric properties of spectroscopically pure, carefully outgassed iron were made through a wide temperature range, including the $\alpha \rightarrow \beta$ and $\beta \rightarrow \gamma$ transformation points. Interesting changes in the slope of the temperature-photoelectric current curves for the various monochromatic radiations are shown. Analyses of the data by Fowler's method at different temperatures indicate that the change in photoelectric sensitivity, to be associated with the allotropic states of iron, is explainable more on a change in the number density of free electrons and the transition-probability factor than on a change in the surface work function. The work function of iron at room temperature was found to be 4·70 eV. The variation of the work function for the three allotropic forms α, β and γ is only 0·10 eV. A.

537.312.5 : 538.639

1326. Photoelectromagnetic and photoconductive effects in lead sulphide single crystals. T. S. MOSS. *Proc. Phys. Soc.* [*London*] *B*, **66**, 993–1002 (*Dec.*, 1953).

For the first time bulk photo-effects have been observed in single crystals of lead sulphide. Both photoelectromagnetic and photoconductive measurements have been made, and carrier lifetimes and quantum efficiencies estimated therefrom. Quantum efficiencies are near unity for all samples, while lifetimes are found to range from 6×10^{-10} to 9×10^{-6} sec. Measurements on lifetimes by two other methods give values in reasonable accord with the photoelectromagnetic values. Study of the spectral distribution of sensitivity establishes that there is no appreciable change in quantum efficiency with wavelength except for the rapid fall at 3 μ, thus establishing that photoelectrically there is no difference between the main absorption band and the "tail" band. The optical activation energy (i.e. quantum energy at which sensitivity is halved) is 0·41 eV, and it is concluded that the thermal activation energy is very close to this value. A.

537.312.6

1327. The effect of thermal radiation on the electrical resistance of hydrophilic organic films. C. D. NIVEN. *Canad. J. Phys.*, **31**, 1095–105 (*Nov.*, 1953).

When thermal radiation falls on certain organic films it increases their electrical conductivity markedly; these films are all hydrophilic. Gelatin showed this effect in the most satisfactory manner but the noise in the film was quite large. In some cases the relative humidity of the air surrounding the film had a definite

influence on the noise but there was apparently some other and more important factor involved which it has not been possible so far to identify and eliminate; consequently the hydrophilic film cannot compete with the inorganic detectors. The films were also found to be electrically sensitive to minute atmospheric pressure changes. A.

537.312.62

1328. Influence of elastic deformations on the superconductivity of tin. C. Grenier, R. Spöndlin and C. Squire. *Physica*, **19**, 833–40 (*Sept.*, 1953) *In French.*

Kamerlingh Onnes and Sizoo studied the effect of mechanical tension and hydrostatic pressure on the transition into the superconducting state using polycrystalline wires of Sn. This is a quantitative continuation of their work and a single crystal of spectroscopic purity was used with a tension and compression force for elastic deformation. The results are compared with Gorter's two fluid electron model of superconductivity and show that the tension force increases the energy gap between the superconducting and normal state. This would seem to support the Fröhlich–Bardeen theory of lattice vibration interaction with the electrons to produce superconductivity. A.

537.312.62

1329. A new thermal resistivity maximum in superconducting alloys. R. J. Sladek. Letter in *Phys. Rev.*, **91**, 1280 (*Sept.* 1, 1953).

The thermal resistivity of superconducting long rods of alloys of In with from 15 to 50 atomic per cent of Tl as a function of longitudinal magnetic field shows at sufficiently low temperature a maximum in the region where superconductivity is almost completely destroyed. On reduction of the field from a high value the thermal resistivity shows hysteresis and for zero field has a value about equal to the maximum. These effects, similar to those found previously in pure metals in transverse fields, are interpreted in terms of the breaking up of the metal into normal and superconducting regions.

D. SHOENBERG

537.312.62

1330. Penetration depth of superconductors. M. C. Steele and M. F. M. Osborne. Letter in *Phys. Rev.*, **91**, 1281 (*Sept.* 1, 1953).

A model of a superconductor in which electrons move in parabolic potential wells gives the relation $\lambda_0 = 1{\cdot}6(\hbar c/eH_0)^{\frac{1}{2}}$ between penetration depth and critical field at 0°K. This relation which, apart from the numerical factor is the same as one proposed by F. London [Abstr. 776 (1945)] gives values of λ_0 about $2\frac{1}{2}$ times higher than found in the most accurate experiments, but agrees roughly with some less reliable data. D. SHOENBERG

537.312.62

1331. Superconductivity in tin-bismuth and tin-antimony alloys. W. F. Love. *Phys. Rev.*, **92**, 238–43 (*Oct.* 15, 1953).

The Meissner effect in a series of spherically shaped solid solution alloys of these metals has been investigated. Magnetization curves have been obtained as a function of temperature and composition, from which critical field curves and transition temperatures have been derived. Increasing breadth of the magnetization curves and frozen in moment have been observed with increasing solute concentration. Thermodynamic analysis of the critical field data has shown an interesting variation of the electronic specific heat coefficient γ with solute concentration, which has been interpreted in terms of the overlapping band structure of tin. A.

537.312.62

1332. Superconductivity of titanium. M. C. Steele and R. A. Hein. *Phys. Rev.*, **92**, 243–7 (*Oct.* 15, 1953).

Critical magnetic fields of two specimens of titanium have been measured down to 0·23°K. The first specimen was a cold-worked Ti wire having a purity of 99·98%. It was found to be superconducting at 0·37°K in zero magnetic field and the initial slope of the critical field curve was 465 gauss per degree. The second specimen was a Ti crystal bar with a purity greater than 99·9%. Its transition temperature was 0·49°K and the initial slope of the critical field curve was 400 gauss per degree. A.

537.312.62

1333. Superconductivity of technetium. J. G. Daunt and J. W. Cobble. Letter in *Phys. Rev.*, **92**, 507 (*Oct.* 15, 1953).

Critical temp. $T_c = 11{\cdot}2°\text{K}$, $(\partial H/\partial T)_{T=T_c} = 300$ to 400 gauss/deg. An exceptionally high value of T_c has been expected from Daunt's empirical rule [Abstr. 2701 (1951)], after it had been found that the room temperature paramagnetism and therefore probably the electronic specific heat per volume of Tc is about 4 times that of Re, which has $T_c = 2{\cdot}42°\text{K}$.

H. LONDON

537.312.62

1334. The intermediate state of a hollow superconducting tin cylinder. J. Gittleman. *Phys. Rev.*, **92**, 561–5 (*Nov.* 1, 1953).

Small bismuth probes were used to measure the magnetic field inside and outside a long, hollow, thin-walled superconducting cylinder, both as a function of the applied field and as a function of the angular position of the probes. From the variation of the magnetic field the structure of the cylinder in the intermediate state was inferred. It would appear that with the onset of the intermediate state "windows" are formed at the poles of the cylinder. These "windows," through which the applied magnetic field can penetrate into the interior of the cylinder, probably consist of the usual rapidly alternating layers of normal and superconducting metal. The parts of the cylinder around the equator remain wholly superconducting until the applied field becomes equal to the critical field, at which time the entire cylinder becomes normal. The intermediate state for the particular cylinder used in this experiment begins to appear at about $0{\cdot}3H_c$, instead of at $0{\cdot}5H_c$. It will be shown in a subsequent paper that this value is a function of the ratio of the inner and outside radii of the hollow cylinder. A.

537.312.62

1335. The transition into the intermediate state of hollow superconducting cylinders. B. Serin, J. Gittleman and E. A. Lynton. *Phys. Rev.*, **92**, 566–8 (*Nov.* 1, 1953).

The transition from the superconducting to the

intermediate state has been investigated for hollow tin cylinders with various ratios of inner to outer radii. Thermodynamic arguments show that for values of this ratio greater than $(2^{\frac{1}{2}}/2)$ the free energy in the normal state becomes less than that in the superconducting state at applied fields less than one-half the critical field. The experimental results indeed show that for ratios of inner to outer radii greater than $(2^{\frac{1}{2}}/2)$ the intermediate state begins to appear at less than one-half the critical field, whereas for smaller ratios the intermediate field appears at one-half the critical field. A.

537.312.62 : 536.631

1336. The heat capacities of superconducting and normal tantalum. R. D. Worley, M. W. Zemansky and H. A. Boorse. Letter in *Phys. Rev.*, **91,** 1567 (*Sept.* 15, 1953).

The specific heat in the normal state followed an $aT + bT^3$ law from 5·1°K down to about 3°K but decreased less rapidly below 3°K and at 1·8°K was about 20% higher than the value obtained by extrapolation of this law. In the superconducting state a T^3 law was followed only at the lowest temperatures, the variation being less steep above about 2°K. See also Keesom and Désirant, *Physica*, **8,** 273 (1941); Mendelssohn, *Nature* [*London*] **148,** 316 (1941).

D. SHOENBERG

537.312.62 : 536.631

1337. The superconducting and normal heat capacities of niobium. A. Brown, M. W. Zemansky and H. A. Boorse. *Phys. Rev.*, **92,** 52–8 (*Oct.* 1, 1953).

Data on the heat capacity of niobium in the normal and superconducting phases are presented in the temperature interval 2·5°K to 11°K. The normal heat capacity c_n was found to be given by the usual relation: $c_n = \gamma T + 464T^3/\Theta^3$, where $\gamma = 20{\cdot}4 \times 10^{-4}$ cal/M deg^2 and $\Theta = 252$°K. The zero field transition temperature T_0 was found to be $8{\cdot}70$°K $\pm$ 0·10°, and the heat capacity discontinuity Δc at this temperature to be 0·0368 cal/M deg. The heat capacity in the superconducting phase was found to depart from a T^3 dependence below 5°K. The entire curve could not be represented by either the Koppe relation or the α model. The H_T *v.* T curve deduced from the heat capacity data was found to be very nearly parabolic, with the value of $H_0 = 2000$ gauss and dH_T/dT at the zero field transition temperature equal to 453 gauss/deg. A.

537.312.62 : 537.311.62

1338. The surface resistance of normal and superconducting tin at 36 000 Mc/s. E. Fawcett. Letter in *Proc. Phys. Soc.* [*London*] *A*, **66,** 1071–2 (*Nov.*, 1953).

The ratio of the superconducting to the normal surface resistance of an electropolished plane single crystal falls gradually from 1 at the critical temp. to 0·01 at 1·3°K and to 0·004 if extrapolated to 0°K. This is an upper limit owing to possible spurious effects. The temperature dependence may be described by the same functions as used by Pippard for results at 9400 Mc/s [Abstr. 8755 (1950)].

H. LONDON

537.312.9

1339. Further measurements of the effect of pressure on the electrical resistance of germanium. P. W. Bridgman. *Proc. Amer. Acad. Arts Sci.*, **82,** 71–82 (*April*, 1953).

In previous papers [see *Proc. Amer. Acad. Arts Sci.*, **67,** 305–44 (*Dec.*, 1932); *ibid*, **68,** *No.* 3, 95–123 (*March*, 1933); Abstr. 6213 (1951); 837 (1953)] the author has described the effect of pressure on the resistance of Ge at room temperature. In this paper results are given for *n*-type and *p*-type specimens for temperatures up to 200°C which is in the intrinsic range where the primary contribution to the conductivity is due to the Ge rather than to impurity. The range of pressure is up to 7000 kg/cm^2. In addition, room temperature measurements are given up to 30 000 kg/cm^2. M. R. HOPKINS

537.312.9

1340. Miscellaneous measurements of the effects of pressure on electrical resistance. P. W. Bridgman. *Proc. Amer. Acad. Arts Sci.*, **82,** 83–100 (*April*, 1953).

Results are given for Sn, Pb, Cd, Al, Cu, Te, U, Re, Hf, Gd. Measurements on some metals have been made up to 200°C and 7000 kg/cm^2 to check the author's former generalization that the pressure coefficient of resistance is approximately independent of temperature. Advantage has been taken of the availability of some of the metals in a higher state of purity than has been possible before. Measurements for T_c are given in the 700 kg/cm^2 range up to 200°C and in the 30 000 kg/cm^2 range at room temperature. Results for U are given up to 30 000 kg/cm^2 at room temperature and previous work on Hf has been extended to 30 000 kg/cm^2 and 100 000 kg/cm^2 at room temperature. Some determinations have been made of the shearing strength of a few of the metals up to pressures of 100 000 kg/cm^2 and also of the cubic compressibility of Gd. M. R. HOPKINS

537.312.9

1341. The effect of pressure on several properties of the alloys of bismuth-tin and of bismuth-cadmium. P. W. Bridgman. *Proc. Amer. Acad. Arts Sci.*, **82,** 101–56 (*April*, 1953).

Measurements have been made of electrical resistance at pressures up to 30 000 kg/cm^2, the pressure being transmitted by a true liquid and at pressures up to 100 000 kg/cm^2, the pressure being transmitted by AgCl. The cubic compressibility has been determined for pressures up to 40 000 kg/cm^2 and the shearing strength at pressures up to 100 000 kg/cm^2. Density, specific resistance and temperature coefficient of resistance have been measured at atmospheric pressure. M. R. HOPKINS

537.313 : 621.311.6 : 621.316.721

1342. A 100 ampere direct current servostabilizer. M. M. Novaković. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3,** 61–8 (*Aug.*, 1953).

A 100 A d.c. supply is stabilized by employing a closed loop stabilization with two channels, for slow changes of input voltage up to 25% of nominal voltage and for fast changes of less than 25% of nominal supply voltage. By this method the output current is stabilized within a maximum variation of 0·05% of the nominal output current. A.

537.32 : 536.7

Irreversible thermodynamics of thermoelectric effects in inhomogeneous anistropic media. *See Abstr.* 1274

537.323

1343. Thermoelectric power of alloys. J. FRIEDEL. *J. Phys. Radium*, **14**, 561–5 (*Nov.*, 1953) *In French.*

Theoretical determination of thermoelectric power of monovalent metals such as copper containing polyvalent impurities such as Zn, Ga, Ge and of aluminium containing transition metals and also Ti and Zr. Agreement with experiment is fairly good.

C. A. HOGARTH

537.323

1344. Thermoelectric power of monovalent metals at high temperature. D. K. C. MACDONALD AND S. K. ROY. *Phil. Mag.*, **44**, 1364–70 (*Dec.*, 1953).

The band theory of metals is applied to analyse the thermoelectric power of "simple" metals at high temperatures. The conventional analysis is first carried through for entirely free electrons and then extended to include variation in number of free electrons per atom, departure from a quadratic dependence of energy on wave number, and non-spherical Fermi surface. Consideration of the data on the alkali and noble metals shows potassium to present a special problem in interpretation. A.

537.363

1345. Reduction of liquid flow in paper electrophoresis. M. A. JERMYN AND R. THOMAS. Letter in *Nature* [*London*] **172**, 728–9 (*Oct.* 17, 1953).

Discusses the elimination of liquid movement in paper electrophoresis. Hydrostatic flow can be eliminated by arranging a siphon between the vessels. The use of buffer-saturated paper completely arrests the inward flow from the ends of the paper, replacing it by a very slight outward flow. The electro-osmotic flow can be reduced by the treatment of paper with periodic acid. F. LACHMAN

ELECTRIC DISCHARGES 537.52

537.521 : 537.562

Theory of ionized media with distant walls. *See Abstr.* 1431

537.521.7

1346. Ions and barriers in electrical discharges. G. K. M. PFESTORF AND R. S. N. RAU. *J. Indian Inst. Sci. B*, **35**, 179–86 (*Oct.*, 1953).

Investigations have been undertaken to study the effect of the injection of ions (both positive and negative) into a spark gap and to compare the results with the "streamer theory" developed by Loeb, Meek and Raether. The effect of paper screens in blocking the ions has also been studied with and without injected ions. AUTHOR

537.523

1347. Screens in long discharge gaps. H. NORINDER AND O. SALKA. *Ark. Fys.*, **6**, *Paper* 17, 151–69 (1953).

The individual stages of the pre-discharge lead to movement of the electrons. With positive discharges, the electrons are drawn upward toward the anode sphere, and with negative discharges they are spouted into the gap. Therefore, the upper surface of a screen of insulating material is subjected either to a "suction" or to a jet of electrons, according to the respective case. Both give rise to Lichtenberg figures. The charge which is thus drawn from the screen or imparted to it is localized in these figures, and the polarity of the figures depends on the way in which the charge moves. Positive discharges impart positive charge to the screen, of a low density, which is not sufficient to start a new pre-discharge from the lower surface of the screen. The screen thus checks the development of the discharge and raises the breakdown voltage in this case. When the screen is near the upper electrode, the density of the charge on it is so high that this effect is insignificant. A screen placed near to the plate gives rise to a spark between the plate and the screen, and this starts a cathode plasma channel. With negative discharges, the screen is sprayed with charge, and acquires a charge of such high density that it acts like an advanced electrode. New pre-discharges arise without difficulty from the lower surface of the screen. The screen aids the development of the discharge, and the breakdown voltage is usually lowered. The form of the Lichtenberg figures is determined by the direction of the movement of the electrons on the surface of the screen. The positive figures appear when electrons are drawn away and the negative figures when electrons are deposited. A.

537.523 : 537.56

1348. A condition on uniform field breakdown in electron-attaching gases. R. GEBALLE AND M. L. REEVES. *Phys. Rev.*, **92**, 867–8 (*Nov.* 15, 1953).

The usual form of breakdown potential curves indicates that at large pd an asymptotic value of E/p seems to exist, below which breakdown does not occur. A study of the equation for steady-state current in electron-attaching gases suggests that this $(E/p)_{\text{lim}}$ is nearly that for which the ionization and attachment coefficients are equal. Substantial agreement is found in CCl_4, CF_3SF_5, CCl_2F_2, SF_6, air, and O_2 between values of $(E/p)_{\text{lim}}$ so determined and those found experimentally. The order of $(E/p)_{\text{lim}}$ for these gases corresponds closely to that of their dielectric strengths. A.

537.523.4

1349. The calculation of spark characteristics with resistance and inductance in the circuit. W. WEIZEL. *Z. Phys.*, **135**, *No.* 5, 639–57 (1953) *In German.*

This deals with the solution of certain differential equations relating the energy dissipation in a spark channel, and the current and voltage drop in LCR circuits. Certain simplifying assumptions are made, for example that radiation losses from the channel are negligible. J. D. CRAGGS

537.523.4

1350. Instrumental treatment of the differential equation of a spark discharge. A. WALTHER AND K.-J. LESEMANN. *Z. Phys.*, **135**, *No.* 5, 658–64 (1953) *In German.*

The equation is solved by means of an instrument described in Abstr. 647 (1950). The solution is presented for a set of values of the relevant parameter.

L. S. GODDARD

537.523.4 : 535.33

1351. Absorption investigations in controlled spark discharges. J. VAN CALKER. Note in *Naturwissenschaften*, **40**, *No.* 16, 434–5 (1953) *In German.*

Describes the absorption, in metallic spectral lines excited in spark discharges, of the background radiation due to a high-pressure Xe arc. Time resolution of the absorption is obtained by means of a rotating mirror technique. J. D. CRAGGS

537.523.4 : 535.33.07

Spectrograph for the time study of sparks. *See Abstr.* 1146

537.523.4 : 551.594.221

1352. The pilot streamer in lightning and the long spark. B. F. J. SCHONLAND. *Proc. Roy. Soc. A*, **220**, 25–38 (*Oct.* 22, 1953).

The absence of significant pulsations on records of the electrostatic field of the stepped leader further establishes the existence of the pilot streamer, which must carry approximately the same current (320 A) and charge per unit length as the leader behind it. Pulsation theories of the stepped leader process are therefore inadmissible. The average radius of pilot and leader streamers in lightning is found to be 2·5 m, thus excluding single-avalanche theories of the step process. A new explanation of the step process is given, according to which the charge on the pilot progressively reduces the field at its starting-point in front of the arrested leader until current ceases, owing to the disappearance of free electrons by capture. A positive "electrode" space charge then develops at this point and in 3 μsec creates a field sufficiently strong for the development of a fast step streamer which overtakes the whole pilot in less than 1 μsec and converts a new section of the channel into a conductor with arc characteristics. The pilot streamer processes in lightning and the long spark have nearly identical velocities, current densities, channel field strengths and ratios of length to radius; it is concluded that they are produced by the same mechanism. It is suggested that the preliminaries to spark breakdown between 1 and 3 MV involve a transition from the narrow electron avalanche to the broad pilot process. A.

537.525

1353. The mechanism of the initiation of an electrical gas discharge under the influence of a transverse magnetic field in the pressure range 10^{-1} to 10^{-8} mm Hg. R. HAEFER. *Acta phys. Austriaca*, **7**, *No.* 3, 251–77 (1953) *In German.*

A detailed experimental investigation to test the theory of discharges proposed by the author to account for initiation of a gas discharge in a non-uniform electric field under the influence of a transverse magnetic field when the mean free path λ is large compared with the diameter D of the cycloidal path of the electrons. Calculation of the sparking potential as a function of magnetic induction × electrode separation for different pressures gives good agreement with experiment. Values of the secondary emission due to ion impact at the cathode (γ) and inelastic ion-gas atom collisions (β) are in good agreement with those calculated on the theory.

C. G. MORGAN

537.525.3

1354. Energetics of the adsorption process responsible for the Joshi effect. S. R. MOHANTY. Letter in *J. chem. Phys*, **21**, 1908 (*Oct.*, 1953).

Discusses temporal variations of the response of ozonizer tubes etc., to external irradiation. This response, it is suggested, is due to adsorbed layers on the glass walls of the tube, and takes a finite time to build up. J. D. CRAGGS

537.525.5

1355. An experiment on the radial motion of charged particles from a pulsed arc discharge. N. L. ALLEN. *Proc. Phys. Soc.* [*London*] *B*, **66**, 1087–95 (*Dec.*, 1953).

A systematic investigation was made of the currents drawn to a metal cylinder surrounding a concentric high-current arc in hydrogen in the presence of a longitudinal magnetic field. Characteristic curves show currents drawn with various positive and negative potentials applied to the cylinder. The shape of the curves is discussed qualitatively in terms of the radial motion of charged particles in the electric and magnetic fields. Consideration is given to the possibility that the action of the arc current, with the magnetic field and electric field due to the cylinder, might produce an appreciable evacuation of gas molecules from the region around the arc column. A.

537.525.8

1356. Influence of irradiation on the characteristic of a glow discharge in pure rare gases. K. W. MEISSNER AND W. F. MILLER. *Phys. Rev.*, **92**, 896–8 (*Nov.* 15, 1953).

Irradiation of the positive column of a glow discharge in pure rare gases by the radiation from a second discharge tube filled with the same gas influences the $V - I$ characteristic of the irradiated glow discharge, shifting it to a higher voltage for the same current. The effect arises from the reduction of the concentration of metastable atoms by absorption. In the case of helium the effect could be studied separately for the two mainly absorbed lines 10 830 Å and 20 581 Å. Practically the whole effect is caused by the latter. This result can be understood by considering the possible transitions involved. A.

537.527.5

1357. Temperature and radiation measurements on water stabilized high pressure arcs. T. PETERS. *Z. Phys.*, **135**, *No.* 5, 573–92 (1953) *In German.*

The arc burns on the axis of a rotating housing containing water. Water vapour formed by the heat of the arc builds up a pressure, which may be maintained at 1000 atmos. for about $\frac{1}{2}$ sec, when the visible spectrum approximates to that of a black body at 12 000°K, the input energy being 200 A, 500 V/cm. At lower pressures, temperatures and electron densities are calculated from the shape of the Hβ line.

G. F. LOTHIAN

X-RAYS 537.531

537.531 : 535.33 : 539.18

1358. Studies of X-rays from Mu-mesonic atoms. V. L. FITCH AND J. RAINWATER. *Phys. Rev.*, **92**, 789–800 (*Nov.* 1, 1953).

A new technique of X-ray spectroscopy of μ-mesonic

atoms has been developed. The X-rays are produced when a μ^- meson undergoes transitions between Bohr orbits about nuclei of various Z. The mesons are produced by the Columbia University 164 in. Nevis cyclotron. The X-rays are detected and their energies are measured to better than 1% accuracy (for $Z \geqslant 22$) using a NaI crystal scintillation spectrometer. The $2p \rightarrow 1s$ transition energies were measured to be 0·35, 0·41, 0·955, 1·55, 1·60, 3·50, 5·80, 6·02, and 6·02 MeV for $Z = 13$, 14, 22, 29, 30, 51, 80, 82, and 83. Special attention was paid to the Pb spectrum, and it is believed that an 0·2 MeV fine structure splitting has been observed. This is the expected splitting if the μ^- meson is a spin $\frac{1}{2}$ Dirac "heavy electron" of 210 electron masses, having the expected Dirac magnetic moment and having no strong non-electromagnetic interaction with nuclear matter. Since the μ^- meson Bohr orbits are 210 times closer to the nucleus than the equivalent electron orbits, the X-ray energies are quite sensitive to nuclear size for medium and large Z. In the case of Pb, a 1% change in nuclear radius gives a 1% change in the calculated X-ray energy. Assuming constant proton density inside a spherical nucleus of radius $R_0 = r_0 A^{\frac{1}{3}}$ and the above properties for the μ meson, the values $r_0 = 1{\cdot}17$, 1·21, 1·22, and $1{\cdot}17 \times 10^{-13}$ cm for $Z = 22$, 29, 51, and 82 are obtained. The significance of these results in relation to other nuclear size measurements is discussed. A.

537.531 : 535.34

1359. Solid-state absorption spectra of Mg and MgO. J. R. Townsend. *Phys. Rev.*, **92,** 556–60 (*Nov.* 1, 1953).

Linear absorption coefficients have been determined for Mg and MgO for wavelengths from 80 Å to 350 Å. The results for Mg have indicated values range from $1{\cdot}8 \times 10^4$ to 12×10^4 cm^{-1}. These values are in reasonable agreement with those extrapolated from the region of the K absorption edge. Surface effects were eliminated by plotting transmission against foil thickness. MgO exhibits three absorption bands in this spectral region. These bands have been tentatively identified and discussed in relation to earlier emission data of O'Bryan and Skinner. A gap of about 4 eV is found to exist between the top filled level and the proposed conduction band. A.

537.531 : 621.386.1

1360. Operation and use of a double X-ray flash tube. G. Thomer. *Z. angew. Phys.*, **5,** *No.* 6, 217–21 (1953) *In German.*

Describes the construction of a continuously evacuated X-ray flash tube, having a Cu target and operating at 40 kV. The tube takes two pictures on the same plate with a time interval that can be as small as 1 μsec. Examples are given of its use in measuring the depth and velocity of plane and cylindrical shock waves in gases, and in showing the spreading out of metallic vapour when a wire is "instantaneously" evaporated. J. THEWLIS (R)

537.531 : 621.386.26

1361. A rotating anode gas X-ray tube. E. A. Owen. *J. sci. Instrum.*, **30,** 393–5 (*Nov.*, 1953).

By using the fine focus made possible by rotating the anode, X-ray beams more intense than those obtained from a stationary anode tube operated under the same conditions, are made available. The target can be changed in a few minutes. The tube is easy to construct and gives a steady output of X-rays free from contamination. A.

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533

1362. Van de Graaff accelerators for sterilization use. F. L. Foster, D. R. Dewey II and A. J. Gale. *Nucleonics*, **11,** 14–17 (*Oct.*, 1953).

The performances of a number of commercially available Van de Graaf electron accelerators are reviewed, with particular reference to their use in sterilizing materials. The methods of utilizing the electron beams to obtain optimum penetration and uniformity of dosage in irradiated samples, are described. Costs of sterilization, using available Van de Graaf generators is briefly analysed.

L. R. SHEPHERD

537.533

1363. Studies on the radiation from electrons in circular accelerators. H. Olsen. *K. Norske. Vidensk. Selsk. Skr., No.* 5, 66 *pp.* (1952).

The main outcome of the whole investigation is, that the results obtained by Schwinger (1946) by application of classical electrodynamics, are confirmed by the quantum mechanical calculation, although the validity of the classical treatment is somewhat more limited than assumed by him, namely to the region below 1000 MeV for a magnetic field of 10^4 gauss. 27 refs. A.

537.533

1364. Effect of anomalous attenuation in a linear accelerator. C. W. Miller and G. Saxon. *Nature* [*London*] **172,** 463 (*Sept.* 5, 1953).

Measurements of attenuation of the 3 m length of guide give about 2·5 db, for low power fluxes, and for power fluxes of several MW. In the presence of a focusing magnetic field, however, an attenuation above 12 db has been observed for 250 kW input power. This does not appear to be dependent on gas pressure within the usual operating range. Heavy beam-loading of the guide brings the mean power down into the region concerned and leads to an abnormally rapid fall-off of beam energy as beam current rises. J. H. FREMLIN

537.533 : 621.384.613

1365. The betatron. R. Wideröe. *Z. angew. Phys.*, **5,** *No.* 5, 187–200 (1953) *In German.*

An introductory review in which the following aspects are discussed: the historical development; the theory of the acceleration of electrons in stationary orbits; the injection of the electrons; the expansion of the orbit and the extraction of the beam; and practical constructional details. The applications of the machine are briefly discussed, and the prospects of developing betatrons with higher energy and larger current than at present available. 70 references are given. J. HUGHES

537.533 : 772 : 621.383

1366. Photography with "exo-" and photo-electrons. J. KRAMER. *Z. Phys.*, **135**, *No.* 2, 251–4 (1953) *In German.*

A latent "exo"-electron image is formed on a suitable sensitive surface (e.g. Al_2O_3). The latter is then moved raster-wise over a small aperture above a spark counter which is actuated by any "exe"-electrons. The counter pulses a lamp with a similar small aperture over which is moved a photographic paper with the same motion as the sensitive surface. A black-white image of the original is thus formed.

G. F. J. GARLICK

537.533.1

1367. Johnson noise and equipartition. D. A. BELL. Letter in *Proc. Phys. Soc.* [*London*] *B*, **66**, 714–15 (*Aug.*, 1953).

For background see Abstr. 8476 (1953). Points out that the infinite noise integrals of Nyquist type, derived by Lindsay and Sims, although they appear independent of reactive components, can be shown by Bode's analysis to be expressible in terms of reactive components only, if there is a finite circuit dissipation. The physical interpretation of this is discussed. A. H. W. BECK

537.533.7

1368. High energy bunched beam analyzer. I. KAUFMAN. Letter in *J. appl. Phys.*, **24**, 1413 (*Nov.*, 1953).

The design parameters of a magnetic velocity spectrograph for use in conjunction with a mm wave cavity producing velocity modulation on an electron beam, are briefly discussed. A. H. W. BECK

537.533.7 : 535.371

The penetration of electrons into luminescent material. *See Abstr.* 1198

537.533.72

1369. The focusing of high-energy particles by grid lenses. I. The strength of grid lenses. II. Lens aberrations. M. Y. BERNARD. *J. Phys. Radium*, **14**, 381–94 (*June*); 451–8 (*July–Aug.–Sept.*, 1953) *In French.*

In Pt I, the strengths of various forms of electrostatic grid lenses is calculated from analytic field distributions. It is shown that the lens strength is appreciably greater than any conventional lens, particularly when the excitation voltage is a small fraction of the total particle energy.

Pt II discusses the effect of the grid apertures on the image. It is shown that the resulting disk of confusion is smaller than the grid holes. M. E. HAINE

537.533.72

1370. Numerical computation of the trajectories in the axial symmetric electron-optical system. P. GAUTIER. *J. Phys. Radium*, **14**, 524–32 (*Oct.*, 1953) *In French.*

A three-point recurrence formula for the numerical calculation of electron paths in central systems (electrostatic and magnetic) is derived from the ray equation. Its application to a particular case yields results comparable with those obtained from the two-point formula of Liebmann [Abstr. 1788 (1950)], but with greater ease of computation. The method is extended to consider space charge and chromatic aberration. M. E. HAINE

537.533.72

1371. Numerical integration of the electron trajectory equation. M. LAUDET. *J. Phys. Radium*, **14**, 604–10 (*Nov.*, 1963) *In French.*

A three-point recurrence formula for electron paths in rotationally symmetrical electrostatic and/or magnetic fields is developed. Various approximate expressions are given for the coefficients involved, and, with each of these, ray paths are computed in the case of a magnetic lens for which an exact solution is known. Each computation is carried out with two interval sizes, and an extrapolation formula is applied. The residual errors are compared. M. E. HAINE

537.533.72 : 513.76

1372. Realization of special contact transformations with static electromagnetic fields *in vacuo*. II. G. IWATA. *Progr. theor. Phys.*, **9**, 97–107 (*Feb.*, 1953).

For Pt I, see Abstr. 8458 (1953). Dynamical systems realizing the momentum-co-ordinate transformation and co-ordinate-co-ordinate transformation are enumerated. The stigmatic transformation using an isoenergetic dynamical system is shown to be an orthogonal transformation, so that the design of a stigmatic electron microscope, is impossible. The extended canonical transformation reveals the relativistic stigmatic transformation to be a Lorentz transformation. An example of integrated energy spectrometer is presented. A.

537.533.72 : 621.3.013 : 621.385.833

1373. Spatially alternating magnetic fields for focusing low-voltage electron beams. J. R. PIERCE. Letter in *J. appl. Phys.*, **24**, 1247 (*Sept.*, 1953).

Following descriptions of the "strong focusing effect" devised by Courant and Snyder [Abstr. 907 (1953)], the author reports that spatially alternating magnetic fields of axial symmetry provide advantages in focusing l.v. dense electron beams. The method results in the possibility of a small increase in the r.m.s. field from a given electromagnet, and a considerable saving in size and weight for a permanent magnet. Experimentally, it has been shown that the beam current transmitted through such a system increases with magnetic field to a maximum, and then falls off to zero. Still further increase in field causes transmission to increase again. M. E. HAINE

537.533.72 : 621.318.2 : 621.385.833

1374. Magnetic electron lens aberrations due to mechanical defects. G. D. ARCHARD. *J. sci. Instrum.*, **30**, 352–8 (*Oct.*, 1953).

The electron-optical aberrations due to mechanical defects in magnetic lens pole-pieces are calculated, for several lens geometries and a range of excitations, by a slight modification of the computational procedure of Sturrock [Abstr. 7008 (1951)]. The condition that these aberrations shall not predominate over the combination of spherical aberration and diffraction is taken as a criterion of mechanical tolerance. Tolerances for the alignment of the pole-pieces are shown to be well within the limits of normal workshop practice (for a typical lens: the axes of the two pole-pieces must not be laterally separated by more than

30 μ, nor must the angle between them exceed 0·005 radian). Tolerances for ellipticity of the bore and corrugation of the pole-faces are more stringent (typically: the variation in radius or in distance of the pole-face from the mid-plane must not exceed 0·1 μ). The results are generalized in the form of universal curves, designed to facilitate the assignment of tolerances in the case of lenses of any magnitude or accelerating voltage. A.

537.533.72 : 621.384.6

1375. Vertical focusing in the microtron. J. S. Bell. Note in *Proc. Phys. Soc.* [*London*] *B*, **66**, 802–4 (*Sept.*, 1953).

It is assumed that the magnetic field is uniform and that the whole of the vertical focusing is due to the r.f. fields in the accelerating gap. It is shown that, although the usual first-order term depending on change of velocity in the gap falls off as $(1 - \beta^2)$, there is another term decreasing only as $(1 - \beta^2)^{\frac{1}{2}}$. This is of second-order in field strength and depends on the actual displacement towards the axis during transit of the gap. It is of importance in the microtron owing to the long gaps and high fields used.

J. H. FREMLIN

537.533.72 : 621.385.833

1376. Trajectories in the symmetrical electron lens. L. Jacob and J. R. Shah. *J. appl. Phys.*, **24**, 1261–6 (*Oct.*, 1953).

The complete field plot obtained by "relaxation" was used to determine electron trajectories for parallel incidence at heights up to one-third the bore diameter, from a numerical integration of the trajectory equation using the method of differences. The accuracy attained in this method yields cardinal points to within 1%. It was found that the focal length f_n for a ray of height r_n was given by $f_n = f_0 - br_n^2$, where b is a constant; also, because of the curvature of the principal planes, the distance d_n to the mid-plane follows a law $d_n = c - dr_n^2$ where c and d are constants. A consequence of this is that for the same variation in focal length, the greater the curvature of the principal plane the larger the spherical aberration of the lens. The trajectory tracings indicate that spherical aberration is small at heights up to one-twelfth the bore diameter, but increases with height till at a value of one-third the bore, the percentage change in focal length has decreased by some 40%. Confirmation of focal properties was obtained using the lens in a single stage electron microscope and examining the pincushion distortion in the image of a gauze object. Evaluation of the spherical aberration using the weak lens approximation of Scherzer leads to gross errors both in magnitude and variation, e.g. the aberration does not remain constant with voltage ratio. The experimental data with the electron microscope indicate little or no change in aberration with increase in the power of the lens; this does not agree with the results of the mathematical analysis of Ramberg. A.

537.533.72

1377. A new microscope principle. J. M. Cowley. *Proc. Phys. Soc.* [*London*] *B*, **66**, 1096–100 (*Dec.*, 1953).

A high-resolution image may be derived from a large number of "dark-field" images of normal resolution, obtained by varying the angle of incidence of the electron beam in a standard electron microscope. The intensity distribution in each dark-field image is multiplied by an appropriate cosine function. Summing gives the function, for one dimension, $C(x) = \int V(X)G(-X)V(X+x)G(x-X)dX$ where $V(x)$ is the potential distribution in the specimen and $G(x)$ defines the loss of resolution due to lens imperfections in normal micrographs. From this, $V(x)$ may be derived. The practical applications of the method are limited by requirements of specimen and instrumental stability. A.

537.533.72

1378. The motion of electrons in two combined magnetic fields. S. G. Nilsson. *K. Tekn. Högsk. Handl.*, *No.* 72, 22 *pp.* (1953).

In previous calculations [Abstr. 6556 (1952)] the author has investigated the focusing properties of the toroid field. Here the toroid field is combined with a homogeneous field perpendicular to the toroid plane (in accordance with an idea of Professor Kai Siegbahn). The ratio between the strength of the two fields is an available parameter. It was now anticipated that one might find a ratio, giving either two-directional focusing or one-directional focusing of a rather high order, or both. The results of the calculations are mainly negative. For the two limiting cases of dominating homogeneous field and toroid field the properties of the semicircular spectrometer and the solenoid spectrometer respectively are obtained. Ratios lying between these extremes either tend to lower the resolving power of the semicircular spectrometer or make the apparatus lose the two-directional focusing property of the solenoid type. There exists no specially suitable intermediate choice of the ratio between the two fields. The technique developed for finding periodical solutions to differential equations of the type $\ddot{y} + Ay + By^2 + Cy^3 + \ldots = 0$, where $|y| \ll 1$, may be of some general interest. A.

537.533.72

1379. On the magnetic electron spectrometer. M. Sakai. *J. Phys. Radium*, **14**, 570–83 (*Nov.*, 1953) *In French.*

A method is suggested for the comparison of different types of β-spectrometers in terms of the spectrum intensity, and spectrum intensity divided by the product of size (orbit radius) and magnetic energy. As an example, the spiral orbit spectrometer, the 180° spectrometer and the magnetic-lens spectrometer are compared. The above criteria are calculated for optimum operating conditions, and for a resolving power ($W_{\frac{1}{2}}$) characteristic to each type of spectrometer. The two above criteria for the three types of spectrometer in the above order then fall in the ratios: $0{\cdot}212\ W_{\frac{1}{2}}^{\frac{1}{2}} : 0{\cdot}123\ W_{\frac{1}{2}} : 0{\cdot}077\ W_{\frac{1}{2}}^{\frac{1}{2}}$ and $21{\cdot}6\ W_{\frac{1}{2}}^{\frac{5}{2}}/\rho H^2 : 18{\cdot}4\ W_{\frac{1}{2}}^2/\rho H^2 : 3{\cdot}4\ W_{\frac{1}{2}}^{\frac{3}{2}}/\rho H^2$. M. E. HAINE

537.533.73 : 535.42

1380. Analogies between the diffraction of light and the diffraction of electrons by gaseous molecules. L. Brú, M. Pérez Rodríguez and R. Vega. *An. Real. Soc. Espan. Fis. Quim.*, **48**(A), 81–8 (*March–April*, 1952) *In Spanish.*

Monochromatic light was diffracted over a unit formed by an ensemble of slits, with a common axis,

in which all periodicities which a molecule can exhibit were represented. By a suitable choice of the slit areas account was taken of the contribution to the expression of intensity of each of these periodicities. Analysis leads to the expressions similar to those used in the interpretation of the pattern obtained in electron diffraction by gases. These were applied to the cases of benzene and carbon tetrachloride. The positions of the diffraction maxima and minima agreed within little more than 1% with those of the corresponding electron diffraction patterns. Values found for interatomic distances (starting from the relative formula of radial distribution) also agree with the real ones within the foregoing limit. A.

537.533.73 : 548.74

1381. The problem of achromatism in electron diffraction. M. Salvat. *J. Phys. Radium*, **14**, 40 S–41 S (*Oct.*, 1953) *In French.*

Reviews previous proposals for making ring diameters of electron diffraction patterns independent of fluctuations in accelerating voltage, using magnetic lenses. It is also possible to achieve achromatism using electrostatic lens, but this is not easily carried out in practice. The use of a homogeneous magnetic field parallel to direction of incident beam is proposed. If this deviates electrons through 180° about the axis of the incident beam, achromatism is achieved.

J. W. MENTER

537.533.74

1382. A "double" camera for electron diffraction. S. Yamaguchi. *J. appl. Phys.*, **24**, 1305–6 (*Oct.*, 1953).

The method described consists in taking two diffraction patterns simultaneously so that the wavelength of electrons applied to an "unknown" is exactly the same as that for the reference. A.

537.533.74 : 530.145

1383. Scattering of fast electrons. I. Elastic scattering. H. Mitter and P. Urban. *Acta phys. Austriaca*, **7**, *No.* 3, 311–23 (1953) *In German.*

The scattering is considered to third-order in Born approximation, for a Yukawa-type potential $v = Ze \exp[-b(r)]/4\pi r$. In the case $b \to 0$ (Coulomb potential), various terms in second- and third-order diverge. These terms are neglected; it is pointed out that they probably belong to an infinite phase constant and have no observable effects. For the Coulomb case the finite terms are calculated explicitly to third-order. G. E. BROWN

537.533.74 : 530.145

1384. Scattering of fast electrons. II. Bremsstrahlung. H. Mitter and P. Urban. *Acta phys. Austriaca*, **7**, *No.* 4, 436–45 (1953) *In German.*

With the methods employed in Pt I, the differential cross-section for bremsstrahlung is calculated to second-order in Born approximation. For the extreme relativistic region, simplified approximate formulae are given for two cases: (1) when the emitted photon is very weak, (2) when it carries away most of the electron energy. G. E. BROWN

537.533.74

1385. Bremsstrahlung and electron scattering cross sections in Au for 247-MeV electrons and positrons. P. C. Fisher. *Phys. Rev.*, **92**, 420–7 (*Oct.* 15, 1953).

The absolute cross-sections for gold for the top 40% of the bremsstrahlung spectrum have been measured for electrons and positrons of 247 MeV mean energy. A magnetic cloud chamber containing two Au foils was used. The foils were positioned to intercept an electron or alternately a positron beam provided by a magnetic field analysis of the electron-positron pair members produced in a Pb foil situated in the X-ray beam of the 300 MeV betatron. With the possible exception of the top 2% of the spectrum, electron and positron bremsstrahlung were the same. For quantum energies in the interval 0·604 to 0·927 of maximum, the Bethe–Heitler spectrum is $8{\cdot}7 \pm 2{\cdot}3\%$ above the experimental spectrum. In the same interval the Maximon–Bethe–Davies theory agrees with experiment. Scattering by electrons was also observed as a function of energy of the struck or lowest energy electron. For these particles having energies between 20 and 130 MeV, the scattering cross-section ratios of experiment to theory are $0{\cdot}96 \pm 0{\cdot}06$ and $1{\cdot}06 \pm 0{\cdot}08$ for incident electrons and positrons respectively. The cross-section ratio of electrons to positrons in the same energy interval is $1{\cdot}31 \pm 0{\cdot}13$ for experiment and 1·46 for theory. All errors are probable errors. A.

537.533.74

1386. High-energy electron scattering by nuclei. R. W. Pidd, C. L. Hammer and E. C. Raka. *Phys. Rev.*, **92**, 436–7 (*Oct.* 15, 1953).

The Michigan race-track synchrotron has been used as a source of electrons for the study of elastic scattering of 30 to 45 MeV electrons by nuclei of $Z = 46 - 52$ and $Z = 74$. The experimental results for tungsten can be interpreted to give a value of the nuclear radius equal to $(1{\cdot}0 \pm 0{\cdot}1) \times 10^{-13} A^{\frac{1}{3}}$ cm if a constant proton density is assumed for the nucleus. The radius of the tin nucleus is $(1{\cdot}1 \pm 0{\cdot}1) \times 10^{-13} A^{\frac{1}{3}}$ cm. Any discontinuity in r_0 *v.* A at the closing of the $g_{9/2}$ shell is about 1% or less; a step increase of 2% at $Z = 48$ gives a best fit to the lower Z data. A.

537.533.74

1387. Nuclear scattering of electrons and isotope shift. A. R. Bodmer. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1041–58 (*Nov.*, 1953).

The volume dependent isotope shift and the elastic scattering of electrons by nuclei are treated by a method with which they can be simply related. The result already obtained by Feshbach [Abstr. 1862 (1952)] that the *s*-wave scattering due to the finite nuclear size depends only on the volume integral of the potential due to the nuclear charge distribution is derived in a simple manner with a clear indication of the limitations. It is shown that this is then the only information which can be obtained for energies at which only the *s*-wave scattering is important. The isotope shift is calculated taking into account the distortion of the electronic wave function by the nuclear charge distribution using a non-perturbation method due to Broch [*Arch. Mat. Naturvid.*, **48**, 25 (1945)] and is reduced considerably below that obtained with the simple perturbation method. It is shown by the same method as that used for the electron scattering that the isotope shift depends essentially only on the above volume integral and on its difference

between two isotopes. Using the results obtained from the scattering of electrons by Ag and Au by Lyman, Hanson and Scott [Abstr. 1856 (1952)] and assuming that the nuclear radius increases proportionally to $A^{1/3}$ the isotope shift is brought into considerably better agreement with the experimental data. A.

537.533.74 : 530.145

1388. Radiative corrections to the scattering of electrons and positrons by electrons. M. L. G. Redhead. *Proc. Roy. Soc. A*, **220**, 219–38 (*Nov.* 10, 1953).

The e^6 corrections to the Møller formula for the scattering of electrons by electrons and the Bhabha formula for the scattering of positrons by electrons, arising from the interaction of the particles with virtual photons, are formulated using the Feynman–Dyson techniques. After removing ultraviolet divergences by mass and charge renormalization the cross-section still suffers from a logarithmic infrared divergence. This is cancelled by adding on the cross-section for the production of a single real photon of low energy during the collision. The result is evaluated assuming that the maximum bremsstrahlung energy radiated is small compared with the rest energy of the electron, as viewed from the laboratory frame. Non-relativistic and extreme relativistic approximations to the formulae are presented, together with the results of exact calculations for a laboratory energy of $20mc^2$. A.

537.533.74 : 539.152.1

1389. High-energy electron scattering and nuclear structure determinations. R. Hofstadter, H. R. Fechter and J. A. McIntyre. *Phys. Rev.*, **92**, 978–87 (*Nov.* 15, 1953).

Electrons of energies 125 and 150 MeV are deflected from the Stanford linear accelerator and brought to a focused spot of dimensions 3 mm × 15 mm at a distance of 9 ft from a double magnet deflecting system. The focus is placed at the centre of a brass scattering chamber of dia. 20 in. Thin foils are inserted in the chamber and elastically-scattered electrons from these foils pass through thin aluminium windows into the vacuum chamber of a double focusing analysing magnet of the inhomogeneous field type. The energy resolution of the magnet has been about 1·5% in these experiments. This resolution is enough to separate clearly hydrogen or deuterium elastic peaks from carbon peaks in the same scattering target. The energy loss in the foils is readily measurable. In the case of light nuclei, e.g. H, D, Be, C, the shift of the peak of the elastic curve as a function of scattering angle indicates the recoil of the struck nucleus. Relative angular distributions are measured for Be, Ta, Au and Pb. It is possible to interpret these data in terms of a variable charge density within the nucleus. A.

537.533.74 : 539.152.1

1390. Interpretation of electron scattering experiments. L. I. Schiff. *Phys. Rev.*, **92**, 988–93 (*Nov.* 15, 1953).

Experiments on the elastic scattering of fast electrons by several elements, reported by Hofstadter, Fechter and McIntyre (preceding abstract), are interpreted with the help of the first Born approximation. This interpretation of the experiments implies nuclear charge distributions that are peaked at the centre and taper off smoothly. The root-mean-square radii of the charge distributions, and the nuclear Coulomb energies, are, however, in approximate agreement with those computed from the usual uniform charge distribution. The effects of radiation loss and nuclear excitation are discussed qualitatively, and the effect of a nuclear electric quadrupole moment is considered more quantitatively. It is concluded that these effects probably cannot account for the discrepancy between the observed scattering cross-section which decreases monotonically with increasing angle and the diffraction minima and maxima expected on the basis of the Born approximation from a uniform charge distribution with a sharp or moderately rounded edge. Exact calculations of the elastic scattering from various charge distributions are now under way. A.

537.533.75

1391. Some measurements on the absorption of 75–200 keV electrons in aluminium. I. Carlvik. *Ark. Fys.*, **6**, *Paper* 1, 1–16 (1952).

Absorption curves were measured for monoenergetic electrons in the energy interval 75–200 keV, using mica-window G.M. counters as detectors. The measurements were made with two different geometrical arrangements. The geometry does not seem to influence the general shape of the curves very much, except for the thinnest absorbers. The results are compared with existing range-energy relations. A.

537.533.75 : 537.534.75 : 539.166.75 : 539.185.7

1392. Penetration of radiation through a thick slab of isotropically scattering material. I. Kuščer. Letter in *Canad. J. Phys.*, **31**, 1187–8 (*Nov.*, 1953).

The dependence of radiation density on depth is obtained very simply by using the asymptotic properties of the solution for a semi-infinite medium.

P. T. MATTHEWS

537.533.8

1393. Some characteristics of secondary emission from BeCu. F. J. Fitz Osborne. Letter in *Canad. J. Phys.*, **31**, 1189 (*Nov.*, 1953).

An experimental study of the energy distribution of secondary electrons emitted from metals using a radial field retardation method. C. G. MORGAN

537.533.8

1394. On the energy lost by a relativistic ionizing particle in a material medium and on the Čerenkov radiation. P. Budini. *Nuovo Cimento*, **10**, 236–59 (*March*, 1953).

This is studied by considering separately the energy dissipated in the vicinity of the path of the particle and that emitted as Cherenkov radiation. The energy dissipated locally in the excitation of the atoms of the medium is calculated on the lines of the Fermi theory, it being necessary to take into account the damping constants of the bound electrons. In the above energy separation it is found that an essential part is played by the ratio, breadth of spectroscopic lines/density of the medium. The larger this ratio the more favoured is the local energy dissipation compared to that by Cherenkov radiation. The energy loss by ionization is

discussed classically, and a formula derived which is in good agreement with experiments, in particular giving an explanation of the rapid increase beyond the minimum observed in emulsions. Formulae for the calculation of the intensity and spectral distribution of Cherenkov radiation are given and a relativistic increase of this as well as the ionization is predicted in dense media. J. HUGHES

537.533.8 : 538.561 : 538.569

1395. Čerenkov effect at microwave frequencies. M. DANOS, S. GESCHWIND, H. LASHINSKY AND A. VAN TRIER. Letter in *Phys. Rev.*, **92**, 828 (*Nov.* 1, 1953).

10^{-7} W Cherenkov radiation has been detected at a wavelength of 1·25 cm when a 10 kV electron beam bunched at 24 000 Mc/s was passed near to the surface of a slab of polycrystalline TiO_2 (permittivity 105). G. D. SIMS

537.533.9

1396. The decomposition of thin films on bombardment with slow electrons. D. A. WRIGHT AND J. WOODS. *Proc. Phys. Soc.* [*London*] *B*, **66**, 1073–86 (*Dec.*, 1953).

The thresholds are determined for the incidence of electron absorption, decomposition and secondary emission for several types of thin film bombarded with slow electrons. With crystalline barium oxide, electron absorption and decomposition both set in at a bombarding energy near 4 eV, and are intensified at 7 eV. Secondary emission is initiated at 5 eV and increases at 7 eV and 10 eV. The optical absorption threshold is at 3·8 eV, and is attributed to exciton formation; it seems likely that the electron absorption and the decomposition are also due to exciton formation. With oxidized films of barium, crystalline barium oxide is not formed; the absorption and decomposition thresholds are at 7 eV, and the main secondary emission threshold at 10 eV. Decomposition of barium chloride sets in at 5 eV, and of barium sulphate at 7 eV. With films of the alkali halides, the decomposition is intensified at an energy corresponding with the first optical absorption band, having been initiated at a lower energy. A tentative explanation of this is proposed. A.

537.533.9 : 535.11

1397. Visible light from localized surface charges moving across a grating. S. J. SMITH AND E. M. PURCELL. Letter in *Phys. Rev.*, **92**, 1069 (*Nov.* 15, 1953).

If an electron passes close to the surface of a metal diffraction grating, moving with velocity v at right angles to the ruling, the periodic motion of the charge induced on the surface gives rise to radiation with $\lambda = d(c/v - \cos\theta)$, where d is the line spacing and θ the angle between the direction of motion of the electron and the light ray. For electrons of energy around 300 keV the light emitted in the forward direction lies in the visible spectrum. The intensity is small, but the effect can be easily detected. The light is strongly polarized with the electric vector perpendicular to the grating. Higher harmonics appear in considerable intensity at 90°. L. PINCHERLE

537.534

1398. Effect of random rotations of magnets on the resonance bands in a strong-focusing cosmotron. J. SEIDEN. *C.R. Acad. Sci.* [*Paris*] **237**, 560–2 (*Sept.* 14, 1953) *In French.*

Possible coupling between the radial and vertical oscillations of the beam and the periodic forces introduced by a small rotation of one of the magnet sections is investigated. It is shown that the effect is of the second order in α_i, the angle of twist, and that, for a practically reasonable value 0·005 radian for α_i, the effect can be neglected. J. H. FREMLIN

537.534.72

1399. Methods and applications of mass spectroscopy. [Methoden und Anwendungen der Massenspektroskopje.] H. EWALD AND H. HINTENBERGER. *Weinheim/Bergstrasse: Verlag Chemie*, 288 *pp.*

Review in *Brit. J. appl. Phys.*, **4**, 319 (Oct., 1953).

537.534.72

1400. A simple mass spectrometer for analysis of stable tracer elements. E. H. COOKE-YARBOROUGH AND M. C. B. RUSSELL. *J. sci. Instrum.*, **30**, 474–80 (*Dec.*, 1953).

Some features are described of a 180° mass spectrometer designed for isotope abundance measurement. The ion current is amplified by a d.c. amplifier and the method of measurement, noise origins and circuits for stabilizing the ion beam are discussed. The accuracy and range are sufficient for the majority of stable isotopic tracer experiments with carbon, nitrogen and oxygen. A.

537.534.74

1401. Differential *p-p* elastic scattering cross section at 144, 271 and 429 MeV. J. MARSHALL, L. MARSHALL AND V. A. NEDZEL. Letter in *Phys. Rev.*, **92**, 834 (*Nov.* 1, 1953).

The differential *p-p* elastic scattering cross-section at 90° baricentral angle has been determined at the above energies as $3{\cdot}21 \pm 0{\cdot}11$, $3{\cdot}67 \pm 0{\cdot}34$ and $3{\cdot}42 \pm 0{\cdot}13$ millibarn/steradian respectively. In addition, the differential elastic cross-sections for 429 MeV protons in liquid hydrogen has been measured as a function of angle by a scintillation counter technique which counts both incident and scattered protons individually. Over the range of baricentral angles 28°–90° the deviation from isotropy was not statistically significant, in disagreement with the elastic scattering curve observed by Mott at 435 MeV. D. R. CHICK

537.534.74

1402. Scattering of 9·5-MeV protons by carbon and oxygen. W. E. BURCHAM, W. M. GIBSON, A. HOSSAIN AND J. ROTBLAT. *Phys. Rev.*, **92**, 1266–7 (*Dec.* 1, 1953).

The elastic and inelastic scattering of 9·5 MeV protons by C^{12} and O^{16} nuclei has been studied by means of photographic plates. The 4·43 MeV state of C^{12}, as well as the 6·05, 6·13, 6·9 and 7·1 MeV states of O^{16} have been observed. The angular distribution of the protons elastically scattered by C^{12} and O^{16} has been determined and compared with Rutherford scattering. In the case of the protons inelastically scattered by C^{12}, the angular distribution shows symmetry around 90°. A.

537.534.75

1403. The stopping cross section of gases for protons, 30–600 keV. H. K. Reynolds, D. N. F. Dunbar, W. A. Wenzel and W. Whaling. *Phys. Rev.*, **92**, 742–8 (*Nov.* 1, 1953).

The stopping cross-section of H_2, He, O_2, air, N_2, Ne, A, Kr, Xe, H_2O, NH_3, NO, N_2O, CH_4, C_2H_2, C_2H_4 and C_6H_6 for protons has been measured over the energy range $E_p = 30$–600 keV. An electrostatic analyser measures the energy of protons incident on a gas cell, and the transmitted beam energy is measured with a magnetic spectrometer. The gas cell is closed off with thin aluminium windows. Comparison of the molecular stopping cross-section of the compounds with the values obtained by summing the constituent atomic cross-sections shows that Bragg's rule does not hold for any of these compounds below $E_p = 150$ keV; for NO the additive rule does not hold at any energy studied. Above 150 keV the stopping cross-section of carbon is obtained by subtracting the hydrogen contribution from the values measured for the hydrocarbons. Average ionization potentials are calculated from these measurements. A range-energy relation for protons in air is included. Sources of error are discussed; the probable error of the stopping cross-section measurements varies between 2–4%. A.

537.534.75 : 539.18

1404. Degradation and range straggling of high-energy radiations. U. Fano. *Phys. Rev.*, **92**, 328–49 (*Oct.* 15, 1953).

A general analysis of the energy spectrum is presented. A method of calculation is developed, which requires that the differential cross-sections of successive collisions are nearly equal. This method is applied to the slowing down of mesons and other heavy charged particles. The same requirement on the cross-section for successive collisions underlies the analysis of straggling into contributions from separate energy intervals traversed in the course of degradation. Successive approximation formulae for the straggling parameters (cumulants) are derived and applied to the case of heavy charged particles. The connections among the theoretical approaches of several authors are discussed. A.

537.534.8

1405. Electronic emission excited by the ionic bombardment of molybdenum and carbon targets. G. Philbert. *C.R. Acad. Sci.* [*Paris*] **237**, 882–3 (*Oct.* 19, 1953) *In French.*

The number of electrons per ion, δ, is independent of the target material. The velocity distribution of the electrons shows a sharp max. at $\simeq 1$ eV. Very few electrons have energies >6 eV. δ depends on the nature of the ions, aliphatic organic molecules being most effective, ions containing an O atom next and rare-gas ions least effective. A. H. W. Beck

537.534.8 : 537.311.33

1406. A study of secondary electron emission from impurity semiconductors. H. Gobrecht and F. Speer. *Z. Phys.*, **135**, *No.* 5, 602–14 (1953) *In German.*

The secondary electron ratio was measured for four Ge crystals of widely varying conductivity σ and for several pure metals and various specimens of Se, as a function of the energy of the primary electrons. In general the ratio increases with primary electron energy up to small values (of order 0·5 to 1·0 kV) and then decreases slowly. For Ge of σ about $1{\cdot}5\times10^3$ higher, the emission ratio is about 7% higher, with a smooth variation between these extremes. The higher values are in general believed to be due to the increased impurity or defect concentrations. C. A. Hogarth

DISCHARGE TUBES . COUNTERS 537.54

537.542

1407. A high frequency ion source. M. B. Nikolić and M. U. Crnilović. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3**, 29–41 (*Aug.*, 1953).

Describes the performance of an ion source, for nuclear work, similar to that due to Thonemann. A proton current of 1·1 mA at 1 m was obtained, using a 60 Mc/s oscillator at 400 W excitation energy. The source gas pressure was $\sim10^{-2}$ mm Hg. The canal was 4 mm in diam. and 15 mm long. J. D. Craggs

537.542

1408. Preliminary experimental results with an ion source with annular extraction. J. Sommeria. Letter in *J. Phys. Radium*, **14**, 555 (*Oct.*, 1953) *In French.*

The ion source is a modified Heil type. For a magnetic field of 1500 gauss, a gas pressure of $1{\cdot}5\times10^{-3}$ mm Hg, and an applied arc voltage of 450, an electron current of 6 mA gives a 9 mA proton beam with an extraction voltage of 12 kV. J. Hughes

537.542

1409. Tritium counter with hydrogen filling and toluol vapour addition. V. Faltings. Note in *Naturwissenschaften*, **40**, *No.* 15, 409 (1953) *In German.*

Continues earlier work [Abstr. 761 (1951)]. The hydrogen was obtained by reducing water vapour on glowing tungsten. Toluol and xylol were the best quenching agents. Reproducible results were obtained. F. R. Holt

537.542

1410. Deterioration of boron trifluoride counters due to high counting rates. R. K. Soberman, S. A. Korff, S. S. Friedland and H. S. Katzenstein. *Rev. sci. Instrum.*, **24**, 1058–60 (*Nov.*, 1953).

Twenty-two counters were run at counting rates of about 10^6 counts per min in the proportional region until they had all lost their plateaus of voltage *v.* counting rate. This occurred in from 10^8 to 10^9 counts. The pulse heights decreased to the point at which maximum sensitivity of the circuitry failed to record more than 10^3 counts per min, although many more small pulses could be detected on an oscilloscope. Raising the voltage did not restore the pulse heights. The counters did not recover after inactive periods of up to four months. Gas samples from several of the counters were analysed on a mass spectrometer. A theory is proposed which would explain the deterioration on the basis of a negative ion sheath which is formed when the BF_3 dissociates. A.

537.542

1411. Geiger–Müller counters with binary mixtures (rare gas—organic vapour). R. MEUNIER, M. BOUPAS AND J. P. LEGRAND. *J. Phys. Radium*, **14**, 630–4 (*Nov.*, 1953) *In French.*

Discusses the basic requirements (such as the relation between the ionization potential of the organic vapour component and the cathode work function) for quenching in Geiger counters with polyatomic gas quenching. Particular attention is directed towards the u.v. absorption in the vapour, with considerable discussion of the relevant work of Price, Walsh and others on absorption in the vacuum u.v. J. D. CRAGGS

537.542

1412. An analysis of efficiency of mica-window GM counters as a function of electrode geometry. M. M. PETROVIĆ. *Bull. Inst. Nuclear Sci. "Boris Kidrich,"* **3**, 19–22 (*Aug.*, 1953).

By the use of a collimated source of either α- or β-rays the active region of end-window counters was probed. Various parameters, e.g. the angle of entry of the beam, were investigated. J. D. CRAGGS

537.542

1413. A scintillation detector for neutrons of intermediate energy. E. R. RAE AND E. M. BOWEY. Letter in *Proc. Phys. Soc.* [*London*] *A*, **66**, 1073–4 (*Nov.*, 1953).

537.542

1414. The background and ^{14}C detection efficiency of a liquid scintillation counter. B. N. AUDRIC AND J. V. P. LONG. *J. sci. Instrum.*, **30**, 467–9 (*Dec.*, 1953).

Experiments with scintillation counters using *p*-terphenyl in benzene are described. By the use of a combination of steel screening, coincidence counting and pulse height selection the total background is reduced to 30 c.p.m. at room temperature for a counting volume of 20 ml. The C^{14} detection efficiency under these conditions is approximately 40%. Light interaction between the photomultipliers used is almost eliminated by the use of a suitable filter. A.

537.542 : 539.166.08

1415. Gamma-ray energy resolution with NaI–TlI scintillation spectrometers. C. J. BORKOWSKI AND R. L. CLARK. *Rev. sci. Instrum.*, **24**, 1046–50 (*Nov.*, 1953).

A method for preparing and mounting NaI–TlI crystals for scintillation spectrometers which gives high optical efficiency, stability and good γ-ray energy resolution is described. Variations in energy resolution of photomultipliers and NaI–TlI crystals is shown. Approximately 200 eV electron energy loss in a NaI–TlI crystal is required to release a single photoelectron from a photocathode whose efficiency is 60 μA per lumen. A.

537.542 : 612

1416. Scintillation counting and its medical applications. W. V. MAYNEORD. *Brit. J. appl. Phys.*, **4**, 353–8 (*Dec.*, 1953).

The development of scintillation counting in the last few years has depended upon the substitution of a photomultiplier tube for the human eye in the detection of small flashes of light by luminescent materials traversed by radiations. A general description is given of the main types of photomultipliers and luminescent materials suitable for such work. The crystals most used in practice are thallium-activated halides or organic crystals such as anthracene or naphthalene. To a first approximation the amplitude of the light pulse produced by the absorption of high energy particles is proportional to the energy absorbed, so that a scintillation detector is, in essence, a proportional counter. Deviations from this linearity, however, occur particularly with organic luminophors. A short outline is given of the application of scintillation counting techniques to medical problems, to which they are particularly applicable owing to the very high sensitivity and small physical size of the detector. A description is given of needle scintillation counters for the study of the radioactivity of biopsy specimens; 4π counters using a liquid scintillating medium for the study of the radioactivity of samples of blood; the application of scintillation counters in the study of the radioactivity of normal and pathological brain tissue. New dosimeters are described, depending upon the measurement of total luminosity of the crystals exposed to ionizing radiations. They are shown to be sensitive, stable, reasonably independent of wavelength errors and are an important development in clinical radiation dosimetry. A description of a scanning technique is given by which it has been possible to form photographic and visual images of the distribution of radioactive materials. In particular, an equipment is described embodying a "storage tube" used in conjunction with television scanning techniques. A.

537.542

1417. A spark counter with cylindrical symmetry. T. MULLER, M. CROISSIAUX AND S. GORODETZKY. Letter in *J. Phys. Radium*, **14**, 554 (*Oct.*, 1953) *In French.*

The counter comprises a cylindrical anode tube 10 mm diameter and a tungsten wire cathode 0·1 mm diameter along its axis. The anode is slotted to admit a fine beam of α-particles passing through at a selected distance from the axis. In air the counting rate shows a maximum for particles crossing the axis but with 1% CO_2 present the counting rate is much higher and is relatively unaffected by the particle beam position. G. F. J. GARLICK

537.542

1418. Five new photomultipliers for scintillation counting. B. R. LINDEN. *Nucleonics*, **11**, 30–3 (*Sept.*, 1953).

The construction and operating characteristics of five end-cathode photomultipliers with front end diameters ranging between 0·75 in. and 5 in. are described. Ten quadrant-shaped box-type dynodes, coated with an activated silver-magnesium alloy, are employed, and multiplications up to 16×10^6 have been obtained with 145 V/stage. The photocathode sensitivities lie in the range 40–80 μA/lumen. Results of measurements of resolution and pulse height, using an NaI(Tl) phosphor and Cs^{137} source, with a 2 in. diameter tube, under a wide range of operating conditions, are given. L. R. SHEPHERD

537.542

1419. Resolving time of a binary counter: A laboratory exercise. R. A. McConnell. *Amer. J. Phys.*, **21**, 585–9 (*Nov.*, 1953).

This nonquantitative electronic circuit exercise is suitable for beginning or advanced students. The minimum operating time of a binary counter is measured in microseconds by means of a twin pulse generator. The operating cycle of the latter is studied in terms of its oscilloscope patterns. A.

537.542 : 621.318.572

1420. A 50 channel amplitude analyser. F. M. Borelli. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3**, 83–93 (*Aug.*, 1953).

An analyser of the Wilkinson type [Abstr. 7325 (1950)] is described. The output stage is modified to improve counting rate. On a specially constructed register the growth of the spectrum can be observed directly. A.

537.542

1421. Some improvements of the continuous diffusion cloud chamber method. A. B. Milojević, M. A. Cerineo and B. I. Lalović. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3**, 23–7 (*Aug.*, 1953).

Describes expts. using ethyl alcohol vapour, with the bottom of the chamber cooled with liquid air to temps. lying between −100°c and −140°c. Liquid air consumption was about 1 l/hr. The chamber pressures varied up to 4 atmos., using air or methane. Detection of various kinds of particles is discussed. J. D. Craggs

537.542

1422. Low-pressure cloud chamber. R. G. Mills. *Rev. sci. Instrum.*, **24**, 1041–5 (*Nov.*, 1953).

An expansion cloud chamber has been developed which operates at a pressure before the expansion of about 45 mm Hg. Since evaporation is rapid and the temperature very low during the sensitive time of the chamber, the density of the gas is higher after the expansion than before. The composition of the gas before the expansion is approximately 40% water vapour and 60% permanent gas. When the chamber is operated with oxygen or argon, the stopping power of the gas during the sensitive time is 7·6% that of N.T.P. air. When it is operated with helium, the stopping power is 5·7% that of N.T.P. air. A.

537.542

1423. A cloud chamber for the study of particles of low energy. T. C. Merkle and J. L. Need. *Rev. sci. Instrum.*, **24**, 1051–4 (*Nov.*, 1953).

A cloud chamber with a magnetic selection favouring low-energy particles is discussed. Technical aspects of shielding, expansion, mechanism, sweeping field and poisoning troubles are included. Discussion of the present mode of operation for a study of π^- capture in helium is given. A.

537.542 : 535.89 : 621.387

1424. High intensity flash tubes for laboratory purposes. A. B. Milojević and M. A. Cerineo. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3**, 47–55 (*Aug.*, 1953).

Describes in detail the development of flash sources, primarily for Wilson chamber experiments. Xenon fillings were especially studied, and luminous outputs were measured for variations in pressure, and discharge tube dimensions, etc. Energies of up to 1200 joules were used. J. D. Craggs

537.543 : 537.525.8 : 621.387

1425. The effect of cathode irradiation upon self-sustained discharges. W. Kluge. *Z. angew. Phys.*, **5**, *No.* 5, 173–7 (1953) *In German.*

Discusses the effect of cathode photo-emission, with external irradiation, on the current-voltage characteristics of diodes containing low-pressure gases. For example, results are given for an electrode separation of 12 mm, 0·5 mm Hg pressure of neon with an Al–K cathode. J. D. Craggs (R)

537.543 : 621.385.1.029.6

1426. Space-charge conditions in a reflected flow of electrons. J. T. Wallmark. *K. Tekn. Högsk. Avhandl.*, *No.* 88, 14 *pp.* (1953).

Part of a thesis on "Space-charge deflection, a new principle for the control of current in electron tubes." For previous parts see *Proc. Inst. Radio Engrs*, **40**, 41–8 (*Jan.*, 1952), Abstr. 1785 B (1952), Abstr. 357 (1952), 5512 (1953). Some characteristic features of a reflected flow of electrons are described, in particular variations of the virtual cathode and transit time with respect to current. The theoretical results are found to be in agreement with experimental results obtained on reflex klystrons and space-charge deflection tubes. A.

537.543 : 621.385.1.029.6

1427. An investigation of the ultimate performance of space-charge deflection tubes. J. T. Wallmark. *K. Tekn. Högsk. Avhandl.*, *No.* 88, 13 *pp.* (1953).

Concluding part of a thesis; see preceding abstract. The ultimate performance of space-charge deflection tubes is investigated in several respects and a comparison is made with pentodes and multiplier tubes using essentially the same tube structure. Noise may be considerably lower than for conventional multiplier tubes and almost equal to that of pentodes. The transconductance-to-current ratio may surpass the value for conventional tubes by a factor of 2–10. The h.f. behaviour is inferior to that of pentodes. The stability of transconductance may be higher and distortion lower than for conventional multiplier tubes and even pentodes. The current drain may be lower than that of a pentode. A.

537.543 : 621.385.032.216

1428. Gold as a grid emission inhibitor in the presence of an oxide-coated cathode. B. O. Baker. *Brit. J. appl. Phys.*, **4**, 311–15 (*Oct.*, 1953).

Emission measurements have been made on Au-plated Mo and Au-plated Mn–Ni-grids in the presence of an oxide-coated cathode. For grids which cannot be designed to operate below 350°c, a minimum thickness of 1 μ of Au will suppress grid emission. Ag is not so reliable, but is effective in some cases. A.

537.543.2 : 621.385.1.032.2

1429. The motion of idealized vacuum tube filaments under shock. H. S. Thomas. *J. appl. Phys.*, **24**, 1341–2 (*Nov.*, 1953).

Theoretical expressions are found for the displacement of points on an ideal clamped-end string relative

to the end points when the supports are given an acceleration normal to the string length at $t = 0$. The accelerations considered have the form of (1) the Heaviside unit function, (2) the Dirac δ function and (3) the doublet impulse function. Approximate formulae for the maximum displacement of the string are derived for each of the three cases. Possible applications of the results to the problem of filament-grid short-circuits in certain vacuum tubes are briefly discussed. A.

IONIZATION . THERMIONICS 537.56/.58

537.561

1430. An indirect method for determining the ionisation potentials of nonpolar molecules. A. Niini. *Ann. Acad. Sci. Fennicae A I*, *No.* 119, 7 *pp.* (1953).

It is shown, through an extensive comparison of the calculated values and the experimental values that the experimental equation is true for nonpolar liquids. Thus, this equation is suitable for determining the values of the ionization energies of nonpolar substances, when the refractive index, the molar volume (or density) and the latent heat of vaporization are known. The ionization energy is calculated for a number of nonpolar substances. The errors of these values depend, as well as on those of the measured values for the basic quantities, also on the error in the calculated value of the constant k. For some polar substances with small dipole moment an upper limit for the ionization energy is calculated. A.

537.562 : 537.521

1431. Theory of ionized media with distant walls. M. Hoyaux. *Rev. gén. Elect.*, **62,** 421–38 (*Sept.*, 1953) *In French.*

Sums up certain points of the author's theory of ionized media with translational symmetry [Abstr. 9561–2 (1951)], and extends the theory to the case in which the electrodes are near together and the walls relatively remote. Calculations are made of the distribution of ionization and of the relationships between (i) the pressure and electronic temperature and (ii) the charge-carrier concentration on the axis and the current for spherical electrodes. The theoretical results are compared with the results of experiments with a specially constructed hot-cathode mercury vapour tube. The theory is applied to the calculation of the potential drop in a mercury arc rectifier. J. DUTTON

537.564 : 535.215.2 : 535.343.4–32

Photo-ionization of O_2 and N_2. *See Abstr.* 1185

537.564 : 535.343.4–32

Photo-ionization of Ne. *See Abstr.* 1184

537.565

1432. Mobility of ions in air at high pressures. N. Wadjih and J. Grosvalet. *C.R. Acad. Sci.* [*Paris*] **237,** 879–81 (*Oct.* 19, 1953) *In French.*

A short note giving results of measurements of the mobility (k) of negative ions in dry air up to pressures (p) of 7 kg/cm^2. Product $p \times k$ was found to be approximately constant and $\simeq 1{\cdot}84$ kg sec^{-1} V^{-1}. C. G. MORGAN

537.565 : 537.523.3

1433. Mobility spectra of ions formed by positive corona discharge. R. Siksna. *Ark. Fys.*, **6,** *Paper* 28, 279–86 (1953).

The bands of small-ions, formed in the prevailing quantity by corona, were determined with characteristics obtained with a small-ion counter. Besides ions formed by positive corona wire in a larger test-room, bands of small-ions of both polarities formed with a generator of corona ions were investigated with the same method. The difference between the mobility spectra obtained and the difference between the number of positive and negative ions formed by corona under the same conditions show that the mechanism of the production and transformation of corona ions and maybe the ions themselves must also be different for positive and negative polarity. A.

537.568

1434. Electron capture. III. Capture into excited states in encounters between hydrogen atoms and fast protons. D. R. Bates and A. Dalgarno. *Proc. Phys. Soc.* [*London*] *A*, **66,** 972–6 (*Nov.*, 1953).

For Pt II, see Abstr. 3578 (1953). The cross-sections associated with the electron capture processes $H^+ + H(1s) \rightarrow H(1s, 2s, 3s, 4s, 2p, 3p, 4p, 3d, 4d$ and $4f) + H^+$ are calculated. They are used in the evaluation of f_α and f_β, the fractions of the total number of captures which result in H_α and $H\beta$ emission. It is found that f_α and f_β are very small, being only about 0·050 and 0·015 respectively even at the most favourable impact energy (approximately 70 keV). A.

537.568 : 551.510.41

1435. A self-consistent calculation of the dissociation of oxygen in the upper atmosphere. II. Three-body recombinations. H. E. Moses and T.-Y. Wu. *Phys. Rev.*, **91,** 1408–9 (*Sept.* 15, 1953).

For previous part, see Abstr. 9224 (1952). The dissociation region of oxygen molecules is treated in the same "self-consistent" manner already described, except that now the densities of atomic and molecular oxygen have been calculated as functions of the altitude, on the assumption that the main recombination process between oxygen atoms is a three-body nonradiative process. The result of the present work indicates that dissociation occurs at an altitude about 5 km higher than the corresponding previous calculation. Furthermore, the region of dissociation is broader than in the previous model. The maximum atomic density is 0·5 to 1×10^{13}/cm^3. A.

537.583 : 537.311.33

The influence of impurity atoms on flicker noise. *See Abstr.* 1317

COSMIC RAYS 537.591

537.591 : 523.165

1436. Propagation of the cosmic radiation through interstellar space. S. Hayakawa. Letter in *Progr. theor. Phys.*, **8,** 571–2 (*Nov.*, 1952).

It is pointed out that if the primary cosmic radiation is confined to the galaxy by magnetic fields, for a

time corresponding to the absorption mean free path, an appreciable number of electrons and photons should be produced as a result of the decay of mesons produced in nuclear collisions. The photons escape from the galaxy but the electrons should be trapped and it is estimated that the number of these electrons should amount to ~30% that of the protons. The number of electrons actually present in the primary cosmic ray flux is much smaller than this, implying that the primary protons have not traversed more than 3 g.cm^{-2} hydrogen. H. ELLIOT

537.591 : 523.165

Can matter be created out of cosmic radiation? *See Abstr.* 986

537.591.1

1437. On the origin of primary cosmic radiation. T. MATSUMOTO AND M. SUGAWARA. *Progr. theor. Phys.*, **9**, 1–6 (*Jan.*, 1953).

It is shown that two important empirical facts concerning primary cosmic radiation, i.e. (i) the similarity of energy spectra expressed with respect to kinetic energy per nucleon of various nuclei independent of their charge numbers and (ii) fairly abundant existences of heavier nuclei, cannot be explained by any acceleration mechanisms. And it is shown that (i) and (ii) can be understood only if one assumes a new type of element formation, according to which, from nucleon gas of extremely high temperature ($\simeq 10^{13}$ °K) and pressure, various atomic nuclei are created with energy spectra $N(\varepsilon) = C \exp\{-(1+\varepsilon)/kT\}$ (ε = kinetic energy per nucleon) and with ratio $C_p : C_\alpha : C_{CNO} : C_{z>10} = 10 : 1 : 1/20 : 1/60$. The physical inevitability with which this assumption is introduced and its physical significance are discussed. The theory itself of element formation of such a type is not touched upon, but it is pointed out that the introduction of such an assumption is required from present knowledge concerning primary cosmic-ray particles. A.

537.591.1

1438. The variation of the ratio of positive to negative cosmic-ray μ mesons with momentum and altitude. H. A. MOREWITZ AND M. H. SHAMOS. *Phys. Rev.*, **92**, 134–44 (*Oct.* 1, 1953).

I. The mean lifetime of μ^+ mesons in carbon and sulphur has been measured by the delayed coincidence technique. Data for decay times $>2\mu$sec were analysed by the statistical method of Peierls and yield $\tau_s^+ = 2{\cdot}09 \pm 0{\cdot}05$ μsec for the mean life of the μ^+ meson in sulphur and $\tau_c^- = 1{\cdot}92 \pm 0{\cdot}04$ μsec for the mean lifetime of the μ^- meson in carbon. τ_s^+ compares favourably with values found in material of low atomic number, but there appears to be a significant difference between these values and those obtained in high Z materials. Assuming Z^4-dependent capture probability for μ^- mesons, τ_c^- is compatible with other lifetimes determined in materials of higher Z.

II. The integral time distributions of the delayed coincidences obtained above were extrapolated to zero delay time and allowance made for those μ^- mesons which are captured in carbon. These data were used to obtain the μ^+/μ^- ratio at a momentum of 325 ± 70 MeV/c at sea level: $\mu^+/\mu^- = 1{\cdot}06 \pm 0{\cdot}03$. This ratio is compared with other experiments (which also provide good identification of the μ mesons) by plotting all ratios as a function of momentum at the top of the atmosphere (TOA). The best fit to the experimental points is given by the exponential expression: $P = P_0 \exp[\mu^+/\mu^-/K]$, where $P < 4$ BeV/c (TOA), $P_0 \simeq 0{\cdot}165$ BeV/c (TOA) and $K \simeq 0{\cdot}38$. The decrease of the μ^+/μ^- ratio with increasing altitude appears to be well established, although the exact values of P_0 and K are uncertain. A.

537.591.1

1439. Search for highly absorbable negative cosmic-ray particles at sea level. C. E. MILLER, J. E. HENDERSON, D. S. POTTER, W. R. DAVIS, W. M. SANDSTROM, G. R. GARRISON AND F. M. CHARBONNIER. *Phys. Rev.*, **92**, 406–11 (*Oct.* 15, 1953).

A search has been made at sea level for negative cosmic-ray particles (other than electrons) which are absorbed in 147 g/cm^2 of lead and which have momenta greater than that of μ mesons of this range. The momentum and sign of the charge of those particles stopping in the absorber were determined by means of a counter-controlled cloud chamber operated in a magnetic field. During 1400 hours of operation no negatively charged particle in the momentum interval 0·4–1·7 BeV/c was recorded as stopping in the absorber. This result has been used to show that the intensity of negative particles with strong nuclear interaction cannot amount to as much as 0·05% of the total intensity of negative particles in this momentum interval. It has been shown that the local production of negative μ mesons in the momentum interval 0·5–1·0 BeV/c is less than $8{\cdot}8 \times 10^{-5}$ particle/(cm^2 steradian hr metre). A lower limit of $6{\cdot}9 \times 10^5$ g/cm^2 of lead has been set on the removal path length of μ mesons in the momentum interval 0·4–1·6 BeV/c. A.

537.591.1

1440. Atmospheric effects on cosmic-ray intensity near sea level. S. OLBERT. *Phys. Rev.*, **92**, 454–60 (*Oct.* 15, 1953).

The effects of atmospheric temperature and pressure on the μ-meson intensity are studied theoretically for locations near sea level. The analysis is based on a unidimensional equation for the vertical differential intensity of μ mesons, studied originally by Sands. The treatment is rigorous in the sense that it includes the continuous production as well as the ionization losses of μ mesons in the atmosphere. With the help of a newly derived range spectrum of μ mesons at production and the exact expression for the survival probability of μ mesons, a three-term regression formula for the relative changes of the μ-meson intensity is derived and discussed in detail. According to this formula, the relative intensity changes are correlated not only with the average production height and the ground pressure (a customarily employed two-term correlation) but also with the average tropospheric temperature. This additional correlation, resulting from the ionization losses of μ mesons in the air, seems to remove some apparent difficulties in the interpretation of experimental data. In particular, it seems to explain the discrepancies found in the decay coefficients determined from diurnal and seasonal observations, respectively. A.

537.591.15

1441. Distribution of arrival times of air shower particles. P. Bassi, G. Clark and B. Rossi. *Phys. Rev.*, **92**, 441–51 (*Oct.* 15, 1953).

The instantaneous distribution of particles in extensive air showers at sea level has been studied by measuring the relative delays between particles with three liquid scintillation counters. The delays measured were in the range from 5 to 300 mμsec. The sizes of the showers were in the range from 10^5 to 10^6 particles. Using statistical methods of analysis the authors have found that at a given instant most electrons with energies of $\sim$20 MeV lie in a flat disk of thickness between 1 and 2 m. The particles which can penetrate at least 20 cm of lead lie in a disk of thickness between 2 and 3 m. The disk of penetrating particles follows behind the disk of electrons by less than 3 m. The projected zenith angles of the axes of individual showers were found by measuring the delays between widely spaced counters. The standard deviation of a measurement of the sine of the projected zenith angle of a shower was 0·13. The root mean square of the sines of the projected zenith angles was found to be $0{\cdot}24 \pm 0{\cdot}015$. If a $\cos^n \theta$ distribution law is assumed for the projected zenith angles, $n = 15 \pm 1{\cdot}2$. The spatial orientations of the axes of individual showers were determined by measuring the projections of the zenith angles on two mutually perpendicular planes. A.

537.591.15

1442. Multiple cores in air showers. O. El-Mofty. *Phys. Rev.*, **92**, 461–3 (*Oct.* 15, 1953).

Multiple cores in cosmic-ray air showers are difficult to observe because of the overlapping of the cores. After transition to equilibrium with water the cores are much smaller and readily identified. Decoherence measurements of the coincidences between pulses in ionization chambers have been made for depths in water from 0 to 3 m and with separation of the chambers up to 6 m. The decoherence measurements are consistent with an average air shower at 9000 ft which has about 20 cores within a distance of about 5 m from the shower's centre. A.

537.591.15

1443. The general three-dimensional theory of cascade processes. H. Messel and H. S. Green. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1009–18 (*Nov.*, 1953).

A mathematical treatment is given of the general three-dimensional theory of a cascade shower developing in a medium in which the number density of the constituent atoms may vary from point to point. This treatment reduces the work of obtaining all angular and radial moments to a drill. The case of the soft component developing in an extensive air shower initiated by a primary nucleon is worked out as an illustration. A.

537.591.3

1444. The absorption of high energy cosmic ray photons. M. Bruin and J. Clay. *Physica*, **19**, 719–28 (*Aug.*, 1953).

Measurements of the absorption coefficient are reported. Results are given for photons belonging to the continuous radiation as well as for those found in extensive air showers. The absorbers consisted of paraffin, carbon, aluminium, iron, tin and lead. A.

537.591.3

1445. Relative ionization by cosmic-ray μ mesons in a liquid scintillator. R. Baskin and J. R. Winckler. *Phys. Rev.*, **92**, 464–7 (*Oct.* 15, 1953).

Measurements of the rise in energy loss of μ mesons of energy between 385 MeV and 2200 MeV in traversing a xylene solution have been made. The observed pulse-height distribution is compared with the most probable energy loss and median energy loss as found using the Landau theory without a density correction and with a density correction as calculated by Sternheimer. The result of this measurement favours a density correction to the theory of energy loss. A.

537.591.5

1446. Time variation of vertical cosmic rays. Y. Sekido, M. Kodama and T. Yagi. *Rep. Ionosphere Res. Japan*, **4**, *No.* 4, 207–13 (1950).

Vertical intensities of cosmic-ray total component were observed at Nagoya, during the period March, 1949–March, 1950. The maximum apertures of the counter telescopes are $\pm 40°$ and $\pm 12°$. Time variation of vertical cosmic-ray intensity observed with a small aperture counter telescope has the following characteristic features, as compared with that of larger aperture observation: (*a*) larger atmospheric effect, (*b*) larger geomagnetic effect, (*c*) larger diurnal variation, (*d*) larger unusual increase. These facts are attributed to the small energy of primary cosmic rays, or the atmospheric path is smaller than the averaged path of larger aperture incidence. A.

537.591.5

1447. Effects of the geomagnetic field on solar cosmic rays. V. Sarabhai and R. P. Kane. *Phys. Rev.*, **92**, 415–19 (*Oct.* 15, 1953).

The force acting on a charged solar cosmic ray due to the action of the geomagnetic field has been analysed in terms of its components along the E–W, the N–S and the vertical directions. With certain simplifying assumptions, the relative magnitudes of these components and their directions have been determined for specific values of the geographic latitude λ of the place of observation as well as the declination δ and the hour angle t of the sun. The deflection that can be produced in the trajectories of solar cosmic rays is qualitatively discussed in terms of the resulting changes which may be expected in the hour of maximum of the diurnal variation of cosmic rays assumed to be due to particles from the sun. It appears that the hour of maximum should become later with increase of latitude. In a northern latitude, a north-pointing cosmic ray telescope should reveal a diurnal variation with an earlier maximum than a south-pointing telescope. There is a possibility therefore of being able to interpret the experimental results of directional studies of the diurnal variation of cosmic rays in terms of geomagnetic effects. A.

537.591.5

1448. The time variation of cosmic-ray heavy nuclei. V. H. Yngve. *Phys. Rev.*, **92**, 428–35 (*Oct.* 15, 1953).

Two 4×4 Ilford *G*-5 photographic emulsions in contact were exposed to the cosmic radiation in such a way that one plate was moved slowly and uniformly with respect to the other. By this technique it is possible to determine the time at which heavy nuclei

pass through the plates. The plates were exposed above 90 000 feet on June 4, 1952, for 8 hours during the day. A reliable altitude record was available and was used to correct for the altitude changes during the 8 hours. 947 heavy nuclei with more than 10 delta rays per 100 microns, corresponding to Z greater than about 10, were traced through and their time of passage measured. This was done by new techniques which are described in detail. The data have been divided into three time intervals. The intensity during the middle interval between noon and 2 p.m. is greater by $25 \pm 8{\cdot}5\%$ than the average of the other two. It is concluded that this is due to a real fluctuation in the intensity of a cosmic-ray heavy nuclei at the top of the atmosphere. The possibility that this may be due to a dipole magnetic field of the sun is discussed. A.

537.591.5 : 550.385

1449. On the relation between the cosmic ray intensity and the geomagnetic storm. K. NAGASHIMA. *J. Geomagn. Geoelect.*, **3**, 100–16 (*Dec.*, 1951).

During a magnetic storm in the magnetic field of the ring current (S. Chapman, 1937) cosmic-ray intensity decreases. The cause of the decrease is sought, not in the magnetic field, but in the electric field, connected with the magnetic storm. From such a standpoint, the shape of the westward current system which is appropriate to account for the cosmic ray phenomena during the magnetic storm, is discussed. Qualitatively, the results obtained seem to be adequate to explain quite reasonably the observed phenomena of cosmic rays, although, quantitatively, there still remain somewhat questionable points. A.

537.591.5 : 551.524

1450. The annual and diurnal variations of cosmic-ray intensity and the temperature effect. K. MAEDA AND T. SUDA. *J. Geomagn. Geoelect.*, **3**, 18–21 (*April*, 1951).

To estimate the influence of the diurnal variation of the atmospheric temperature on that of cosmic-ray intensity, cosmic-ray intensity data at Huancayo and aerological data at San Juan were investigated. As the mean atmospheric temperature, the altitude differences between 100 mb and 1000 mb levels were used. The amplitude of the diurnal change of cosmic-ray intensity at Huancayo was found to exceed $0{\cdot}5\%$ at least (i.e. twice that of the observed value), if the temperature effect was taken into account. A.

537.591.8 : 778.34

1451. The production of delta-rays in nuclear-research emulsions. D. A. TIDMAN, E. P. GEORGE AND A. J. HERZ. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1019–31 (*Nov.*, 1953).

Theoretical formulae are derived which give the δ-ray density as function of the velocity and charge of the primary particle, taking into consideration the fact that the electrons in the emulsion are both bound and in motion. The two main types of convention used in deciding which configurations of grains are to be accepted as δ-rays are investigated: those in which the δ-rays must contain more than a specified number of grains, and those in which they must reach a specified distance from the primary track. Account is taken, where necessary, of straggling, multiple scattering and the fluctuations in the numbers of grains in electron tracks. The theory is compared with the results of δ-ray counts on the tracks of singly charged particles of known velocity. The agreement is very good in the case of the conventions based on range, and fairly satisfactory for the grain-number conventions. The range conventions are found to be preferable in practice as they are more easily learnt and more objective than those in which numbers of grains have to be estimated. A.

MAGNETISM 538

538.082 : 621.317.444

1452. A recording fluxmeter. R. S. TEBBLE. *J. sci. Instrum.*, **30**, 369–71 (*Oct.*, 1953).

A description is given of a method of recording the deflections of a Grassot fluxmeter. The secondary coil of a mutual inductance is attached to the suspended coil of the fluxmeter and a deflection of the fluxmeter is recorded as a change in a voltage induced in the mutual inductance system. Part of the voltage is fed back to eliminate the torsion effect of the fluxmeter suspension. In the apparatus described, the output voltage is used to produce the Y-deflection of a Leeds Northrup XY recorder and thus to record hysteresis (I–H) curves of ferromagnetic materials; alternative methods of recording, e.g. a c.r.o., can be used. The method is also suitable for use with other instruments, such as galvanometers, which have a rotational movement. A.

538.114

1453. Spin-wave theory of antiferromagnetism for simple cubic lattices. M. R. SCHAFROTH. *Phys. Rev.*, **92**, 533 (*Nov.* 1, 1953).

The transcendental functions which arise in a variational treatment of the spin-wave theory of antiferromagnetism are calculated for the case of the simple cubic lattice. A.

538.122 : 621.318.3 : 621.3.013

1454. The field along the axes of symmetry of equal semi-infinite rectangular magnetic pole-pieces. W. SNOWDON AND N. DAVY. *Brit. J. appl. Phys.*, **4**, 339–41 (*Nov.*, 1953).

The method of conformal representation is applied to a two-dimensional figure representing the cross-section of rectangular pole-pieces having two axes of symmetry. The field at intervals along these axes is calculated accurately for a number of different value of the ratio of width of pole-pieces to distance separating them. The number and range of values of this ratio for which the calculations are made is sufficient to allow of interpolation for any ratio likely to be met with in practice. Expressions are derived for the values of the potential function along the principal axes. A.

538.213 : 621.318.1.013

1455. Complex magnetic permeability of spherical particles. J. R. WAIT. *Proc. Inst. Radio Engrs*, **41**, 1664–7 (*Nov.*, 1953).

The effective complex magnetic permeability of an array of spherical conducting permeable particles is

computed. Curves given illustrate the dependence of the conductivity, permeability and radius of the particle and the frequency. A.

538.221

1456. Anisotropy in the antiferromagnetic MnO_2. K. Yosida. Letter in *Progr. theor. Phys.*, **8**, 259–60 (*Aug.*, 1952).

Extends the theoretical treatment of Keffer [Abstr. 8318 (1952)] to rutile type lattices and calculates the difference in the principal susceptibilities and the anisotropy energy. E. P. WOHLFARTH

538.221

1457. Gadolinium-rich gadolinium-magnesium alloys: preparation and magnetic properties. F. Gaume-Mahn. *C.R. Acad. Sci.* [*Paris*] **237**, 702–4 (*Oct. 5*, 1953) *In French.*

Describes the preparation of alloys containing 68%–100% Gd (by weight). The magnetization was measured as a function of temperature (78°–300°K) and field strength (60–7800 oersted). Two intermetallic compounds with Curie points 103°K (GdMg) and 266°K (roughly Gd_9Mg) were established; the Curie point of pure Gd (289°K) was also measured. See Abstr. 318 (1953) for earlier measurements.

E. P. WOHLFARTH

538.221 : 538.23

1458. The coercive force of iron-cobalt micro-powder magnets. F. Lihl. *Acta phys. Austriaca*, **7**, *No.* 3, 239–47 (1953) *In German.*

Reports measurements of the coercivity, remanence and energy product of Fe–Co micro-powders as dependent on Co content and on the reduction time of the formate crystals from which the powders were prepared. The magnetic hardness increases with increasing Co content, the maximum not having been reached at the highest concentration investigated (36·4% Co). The maximum extrapolated value (infinite dilution) of ${}_IH_c$ was 1000 oersted for this composition. See Abstr. 9593 (1951) for earlier work.

E. P. WOHLFARTH

538.221 : 539.185

Polarization of thermal neutrons by "non-crystalline" ferromagnets. *See Abstr.* 1764

538.221 : 548.7

1459. Ferromagnetic domain processes in single crystal disc specimens of silicon iron. D. H. Martin. Note in *Proc. Phys. Soc.* [*London*] *B*, **66**, 712–14 (*Aug.*, 1953).

Observation of domain patterns on a single crystal of Si–Fe suggest that surface imperfections play an important role in determining the domain structure. A disk parallel to a (100) plane originally magnetized to saturation in a [100] direction, was rotated through 45° in its own plane. The final domain pattern contained domains whose direction of magnetization had no equivalent in the initial condition and these domains were observed to originate as "daggers" at surface imperfections. A. E. DE BARR

538.221 : 669.018 : 621.318.1

1460. Recent progress in the manufacture of magnetic materials. Oriented ferronickel alloys. E. Josso. *Ann. Télécomm.*, **8**, 262–6 (*Aug.–Sept.*, 1953) *In French.*

An account of the preparation and properties of grain-oriented 50% Fe–Ni alloy with a rectangular hysteresis loop. If the recrystallized alloy is subjected to further light reduction the permeability in the rolling direction is constant to within less than 1% at about 100. A. E. DE BARR

538.222

1461. Note on the spin paramagnetism of a free electron gas. N. H. March and B. Donovan. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1104–8 (*Dec.*, 1953).

The effect of exchange on the spin paramagnetism of a free electron gas is discussed. It is shown that in general the exchange terms have a marked effect on the susceptibility and can be legitimately neglected only at extremely high temperatures. A comparison is made with the results of a simple treatment due to Stoner, and qualitative similarities are apparent. A.

538.222

1462. A new spectrograph of the auto-oscillator type. R. Gabillard. *C.R. Acad. Sci.* [*Paris*] **237**, 705–8 (*Oct.*, 1953) *In French.*

With the sample in the inductance of a Colpitts-type auto-oscillator, paramagnetic resonance has been observed in diphenyl picryl hydrazyl at 30 Mc/s in a field of 10 gauss. D. H. WHIFFEN

538.222

1463. Proton magnetic resonance of the CH_3 group. I. Investigation of six tetrasubstituted methanes. J. G. Powles and H. S. Gutowsky. *J. chem. Phys.*, **21**, 1695–703 (*Oct.*, 1953).

Measurements have been made of the proton magnetic resonance absorption in methyl chloroform, 2, 2-dinitropropane, 2-chloro-2-nitropropane, *t*-butyl chloride, *t*-butyl bromide and neopentane, in the solid state. In all the materials at −196°c, except neopentane, the absorption corresponds to CH_3 groups effectively fixed in the lattice. The narrowing of the absorption lines with rising temperature in methyl chloroform, 2, 2-dinitropropane and 2-chloro-2-nitropropane is attributable to the increasing rate of motion of the CH_3 groups about their C_3 symmetry axis. In methyl chloroform at higher temperatures, and in *t*-butyl chloride, *t*-butyl bromide and neopentane an additional motion of the CH_3 groups is required to explain the observed absorption, and possible motions are suggested. In all the polar materials the line becomes very narrow at the thermal transition at which the dielectric constant rises to a high value, marking the onset of overall molecular rotation. In neopentane the line is narrower than expected for the rigid lattice at −196°c. With rising temperature, the line narrows to a very small value between the thermal transition and melting points. Theoretical analyses are given of the effects of external broadening upon the line shapes of fixed and rotating CH_3 systems, and the results are used in interpreting the experimental data. A.

538.222

1464. Proton magnetic resonance of the CH_3 group. II. Solid solutions of *t*-butyl chloride in carbon tetrachloride. J. G. Powles and H. S. Gutowsky. *J. chem. Phys.*, **21**, 1704–9 (*Oct.*, 1953).

Measurements of the proton magnetic resonance absorption in solid solutions of *t*-butyl chloride in carbon tetrachloride are reported for temperatures above −195°c. The results confirm, in general, the

phase diagram established previously by thermal and dielectric measurements. In addition, information is obtained on the CH_3 group and molecular motions in the various phases. Rotation of the CH_3 groups at $-195°C$ depends on the composition. In solutions between 34·9 and 70·6 mole per cent *t*-butyl chloride there is effective rotation of the CH_3 groups about their C_3 axes whereas in pure *t*-butyl chloride the CH_3 groups are fixed at this temperature. For some compositions two separate phases are formed at low temperatures and the observed absorption agrees with that predicted from the properties and relative proportions of the protons in the two phases. Somewhat anomalous results were obtained for the more dilute solutions. For all compositions at temperatures above $-150°C$ the resonance line narrows to about the same value, 3 gauss, and this is shown to be due to rotation of the molecule about the C–Cl bond in addition to rotation of the CH_3 groups about their C_3 axes. Other possible motions are discussed, and the second moment of the absorption line is calculated theoretically for complex motions of the CH_3 group. The differences in the freedom of motion of the CH_3 groups in the different phases are attributed to interactions both within a molecule and with neighbouring molecules. A.

538.222

1465. Temperature change in paramagnetic resonance absorption of solutions of organic free radicals. D. Bijl and A. C. Rose-Innes. Letter in *Phil. Mag.*, **44**, 1187–9 (*Oct.*, 1953).

The absorption of three organic radicals ϕ_2NO, $(p\text{-anisyl})_2NO$ and Banfield and Kenyon's radical in different solvents was studied at about 10 000 Mc/s in magnetic fields of 3000 oersted from room temperature to 90°K. The three nearly equidistant lines obtained at room temperature merge towards a single line on cooling, the changes in pattern depending upon the solvent used. The high temperature pattern is attributed to hyperfine structure due to N^{14} in the NO group. It is unlikely that the changes in relative intensities on cooling can be explained in terms of a hyperfine structure. The constants of the spin Hamiltonian obtained from the data together with the line separations are tabulated. H. H. GREENWOOD

538.222

1466. Paramagnetic resonance hyperfine structure of the free radical $(SO_3)_2NO^=$. B. Smaller and E. L. Yasaitis. Letter in *J. chem. Phys.*, **21**, 1905–6 (*Oct.*, 1953).

A detailed study of the transitions and hyperfine structure due to the spin of the N, especially in weak magnetic fields, gives the zero field splitting, $W_0 = 54·9 \pm 0·2$ Mc/s from the paramagnetic resonance of the K salt of the radical ion $(SO_3)_2NO^=$ in dilute NaOH solution. D. H. WHIFFEN

538.222

1467. Paramagnetic resonance hyperfine structure of V^{50} and V^{51}. C. Kikuchi, M. H. Sirvetz and V. W. Cohen. *Phys. Rev.*, **92**, 109–13 (*Oct.* 1, 1953).

The paramagnetic resonance has been observed of a magnetically dilute crystal of vanadium Tutton salt containing 23% of the isotope V^{50}. The h.f.s. of V^{50} was completely resolved, and hence its spin found to be 6. The ratio of the nuclear *g*-factors, $g(V^{50})/g(V^{51})$, was measured with the result, $0·3792 \pm 0·0008$, in good agreement with the value determined directly by nuclear magnetic resonance experiments. A.

538.222

1468. A dynamic model of magnetic resonance phenomena. F. Verbrugge. *Amer. J. Phys.*, **21**, 603–9 (*Nov.*, 1953).

A dynamic model to illustrate atomic and nuclear magnetic phenomena is described. An air-driven spinning magnetic dipole placed in a magnetic field exhibits a Larmor precession whose dependence on magnetic and gravitational parameters can be demonstrated. An a.c. magnetic field of variable frequency permits a visual demonstration of magnetic resonance. Data obtained from the precession experiments can be used for a precise determination of the earth's magnetic field. A.

538.222

1469. Paramagnetic resonance absorption in solutions of K and Na in liquid NH_3. C. A. Hutchison, Jr and R. C. Pastor. *J. chem. Phys.*, **21**, 1959–71 (*Nov.*, 1953).

The resonance was studied at a frequency of approximately $7·0 \times 10^6$ c/s and a magnetic field of 2·5 gauss. The measurements have been made at 240°K, 274°K and 298°K and over a concentration range from 0·004M to 0·7M. The intensities and susceptibilities, spectroscopic splitting factors, widths, shapes and extents of saturation of the resonances have been determined. The paramagnetic parts of the magnetic susceptibilities in static fields have been calculated from the r.f. data and have been compared with the susceptibilities measured in static fields by other investigators. The relations of the trapped electron model of such solutions to these quantitative measurements on the paramagnetic resonance absorption have been considered. A.

538.222

1470. Exchange coupling in $CuK_2Cl_4.2H_2O$ by paramagnetic resonance absorption. K. Ōno, H. Abe and J. Shimada. *Phys. Rev.*, **92**, 551–2 (*Nov.* 1, 1953).

$CuK_2Cl_4.2H_2O$ contains two inequivalent Cu^{++} ions in each unit cell. At $\lambda = 5·4$ mm two peaks are obviously found corresponding to two different *g* values, whereas only one peak is found at longer wavelengths. From these facts the exchange between these dissimilar ions is estimated to be about $0·1\ cm^{-1}$. For the crystal orientation relative to the magnetic field at which the two types of ions are similar, the line width decreases with decreasing wavelength. This may be the result of the "10/3 effect" discussed by Anderson and Weiss [Abstr. 8514 (1953)]. A.

538.222

1471. Saturation effects in paramagnetic resonance. A. H. Eschenfelder and R. T. Weidner. *Phys. Rev.*, **92**, 869–73 (*Nov.* 15, 1953).

Saturation effects have been observed in the paramagnetic resonance absorption of 3·2 cm microwaves by diluted samples of iron ammonium alum and chromium potassium alum at 2 to 4°K. For all

samples the spin-lattice relaxation time T_1 was found to vary inversely with the temperature, in agreement with theoretical expectation that the direct rather than the "Raman" process for the spin-lattice quantum transfer predominates at helium temperatures. Diluted samples of iron ammonium alum with iron to aluminium atom ratios of 1 : 18, 1 : 59 and 1 : 80 showed T_1 to be essentially independent of dilution and yielded $TT_1 = 5\times10^{-4}$ sec °K for the $m = \frac{1}{2} \rightarrow -\frac{1}{2}$ transition. The low-field side peak in the iron alum spectrum for the (100) orientation, comprised of two unresolved transitions, yielded an effective value of $TT_1 = 1{\cdot}4\times10^{-3}$ sec °K. The $m = \frac{1}{2} \rightarrow -\frac{1}{2}$ transition for diluted chromium alum with a chromium to aluminium atom ratio of 1 : 10 yielded $TT_1 = 3\times10^{-3}$ sec °K in agreement with the calculated value. In all samples the spin-spin relaxation time was found to be temperature independent and of the order of 10^{-9} sec. The results for T_1 are at variance with those obtained with low-frequency paramagnetic relaxation experiments, which show a faster temperature dependence than T^{-1} and an increase in T_1 with dilution. A.

538.222

1472. Nuclear quadrupole resonance of the stable gallium isotopes. H. G. DEHMELT. *Phys. Rev.*, **92**, 1240 (*Dec.* 1, 1953).

Eight absorption lines have been observed in a sample of polycrystalline $GaCl_3$. Of these, six are ascribed to the Cl isotopes. The remaining two, which are due to the stable gallium isotopes $Ga^{69,71}$, allow the ratio of their quadrupole moments to be determined. $Q^{69}_{Ga}/Q^{71}_{Ga} = 1{\cdot}5867 \pm 0{\cdot}0004$, in agreement with earlier atomic beam measurements. A.

538.222 : 539.152.2

1473. On the equivalence of moment method and Fourier transform method in the theory of spectral line shape. I. YOKOTA. Letter in *Progr. theor. Phys.*, **8**, 380–1 (*Sept.*, 1953).

Van Vleck's method for the analysis of magnetic resonance absorption is shown to be equivalent to the method of Fourier transform which is often used in the theory of pressure broadening of spectrum lines. L. PINCHERLE

538.224 : 541.64

1474. Magnetic study on high polymers. I. Diamagnetic anisotropy of natural rubber. A. ISIHARA, H. KUSUMOTO, H. NAGANO AND K. OSHIMA. *J. chem. Phys.*, **21**, 1909–11 (*Nov.*, 1953).

The magnetic anisotropy of natural rubber was measured by Krishnan's oscillation method. In the first place, the anisotropy was measured by varying the time of vulcanization and was found to decrease with the time of vulcanization. In the second place, the anisotropy was measured as a function of temperature. Similar to the breadth of nuclear magnetic resonance line, an abrupt change in the slope of the anisotropy *v.* temperature curve was observed at the second-order transition temperature. Above and below this transition temperature, its change with temperature was not so strong. A.

538.224 : 541.67 : 539.133

Magnetic properties and structure of molecules. Contribution to the study of the delocalization of electrons. *See Abstr.* 1540

538.24 : 550.38

1475. Self-reversal of thermo-remanent magnetization of igneous rocks. T. NAGATA. *Nature* [*London*] **172**, 850–2 (*Nov.* 7, 1953).

Two samples have been found in Japan which show this effect in laboratory experiments. The composition and properties of the ferromagnetic minerals separated from these rocks are closely similar. The mineral grains have a mean diameter of 0·1–0·5 mm, and can be separated magnetically into three groups, those (A) having a Curie point 500–530°c, those (B) having a Curie point <300°c and those containing both A and B constituents. The A and B grains show normal thermo-remanent magnetization, but the AB-grains give a reversed magnetization on cooling in a weak magnetic field. The magnetic properties of the B-constituent are unusual, but are just those required for Néel's two-phase theory of the mechanism of reverse thermo-remanent magnetization. This mechanism may not account for the natural reversed magnetism found in many other localities because the occurrence of the B-mineral appears to be rare. Its magnetic properties present a new problem in crystal physics. A. T. PRICE

ELECTROMAGNETISM . ELECTRODYNAMICS
538.3/.5

538.3

1476. A simple formulation of the unquantized laws of electrodynamics. O. BUNEMAN. Letter in *Nature* [*London*] **172**, 859–60 (*Nov.* 7, 1953).

An effective current-density 4-vector $\mathbf{A(r)}$ is derived by integrating $2\mathbf{J(r')}\delta[(\mathbf{r}-\mathbf{r'})^2]$ over space and the entire past, where $\mathbf{J}$ = magnitude of charge density × the 4-vector velocity $\mathbf{U}$, the sign of the charge being absorbed in $\mathbf{U}$. The Maxwell–Lorentz laws are then summarized as "$\mathbf{U} + \mathbf{A}$ maintains constant circulation." R. A. NEWING

538.3

1477. A new modification of classical electromagnetic theory. A. SCHILD. *Phys. Rev.*, **92**, 1009–14 (*Nov.* 15, 1953).

A fundamental particle is treated as a unit charge whose rest mass and space-time co-ordinates are variables of its motion. Classical electrodynamics, in its action-at-a-distance formulation, is obtained from an action principle which is simpler than the usual one. In this new action principle the rest mass of a particle is varied as well as the co-ordinates. The rest masses of interacting particles, although not assumed constant *a priori*, become constants as a consequence of the equations of motion. Modifications of the old action principle can yield purely electromagnetic rest masses which are, however, the same for all particles. Similar modifications of the new action principle give purely electromagnetic rest masses to all charged fundamental particles. In this new modification of electrodynamics, particles interacting at small distances no longer have constant rest masses. A.

538.3

1478. A scalar representation of electromagnetic fields. H. S. GREEN AND E. WOLF. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1129–37 (*Dec.*, 1953).

It is shown that in a region which is free of currents and charges, any electromagnetic field may be rigorously derived from a single, generally complex, scalar wave function $V(\mathbf{x}, t)$. In terms of this function the momentum density $g(\mathbf{x}, t)$ and the energy density $w(\mathbf{x}, t)$ of the field may be defined in such a way that they are represented by expressions analogous to the formulae for the probability current and the probability density in quantum mechanics; in a homogeneous isotropic medium

$$\mathbf{g}(\mathbf{x}, t) = -\frac{1}{8\pi\mu_0 c}[V^*\nabla V + V\nabla V^*],$$

$$w(\mathbf{x}, t) = \frac{1}{8\pi}\left[\frac{\varepsilon_0}{c^2}VV^* + \frac{1}{\mu_0}\nabla V . \nabla V^*\right]$$

The densities defined in this way differ from those given by the usual expressions, but the choice is justified since the differences disappear on integration over any arbitrary macroscopic domain. (The corresponding Lagrangian densities differ by a four divergence.) When V is of the form $V_0(\mathbf{x})e^{-iwt}$, $\mathbf{g}$ is found to form a solenoidal field which is orthogonal to the co-phasal surfaces arg V_0 = constant. A.

538.3 : 621.3.011

1479. A short modern review of fundamental electromagnetic theory. P. HAMMOND. *Instn Elect. Engrs Paper* 1595, 10 *pp.* [To be published also in *Proc. Instn Elect. Engrs*].

The paper is concerned with the teaching of the fundamentals of electromagnetism. Part 1 deals with a method of presenting electromagnetic concepts to the student which takes the inverse square law of force between magnetic poles or electric charges as its starting points. This method is considered to result in a more satisfying sequence of thought than that usually adopted, because the symmetry of magnetic and electrical relations is stressed. Part 2 is a detailed discussion of the teaching of Faraday's laws of electromagnetic induction. Part 3 is a presentation of Maxwell's equations in terms of electric and magnetic flux density. A.

538.311

1480. The equivalence of steady electric currents and magnetic shells. T. SEXL. Note in *Acta phys. Austriaca*, **7**, *No.* 2, 198–9 (1953) *In German.*

Shows that the relation for the magnetic field due to a magnetic shell (equivalent to a closed electric circuit carrying a steady current) may be transformed to the Biot–Savart law without using the concept of the vector potential. E. P. WOHLFARTH

538.52

1481. Induction phenomena due to the motion of matter in primary magnetic fields, and the possibility of their experimental application. II. Translations. H. HINTEREGGER. *Acta phys. Austriaca*, **7**, *No.* 2, 129–45 (1953) *In German.*

The theory is developed of the fundamental experimental facts reviewed in Pt I [Abstr. 6963 (1953)], dealing in particular with the definition of the apparent dielectric constant, with the extension to magnetic bodies of Sommerfeld's treatment of unipolar induction, and with the identification of translational unipolar induction as the electrostatic induction in the system of reference attached to the moving body. L. PINCHERLE

538.52

1482. Induction phenomena due to the motion of matter in primary magnetic fields and the possibility of their experimental application. III. Theoretical foundation for the understanding of the general case. H. HINTEREGGER. *Acta phys. Austriaca*, **7**, *No.* 4, 337–54 (1953) *In German.*

The application of a modified form of the Maxwell–Lorentz theory is particularly discussed in which curl $H = \partial D/\partial t + \rho v + \sigma(E + v \times B)$, all symbols having their usual meaning. The cases discussed in detail are: pure stationary case with non-vanishing conductivity; induction with and without currents; the special case of an ideal conductor; the effect of eddy currents for normal values of the conductivity. L. PINCHERLE

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.561

1483. Magneto-ionic theory of weakly ionized gases in the presence of an oscillating electric field and of a constant magnetic field. R. JANCEL AND T. KAHAN. *J. Phys. Radium*, **14**, 533–40 (*Oct.*, 1953) *In French.*

Theoretical derivation, on the basis of the Boltzmann differential equation, of the electronic velocity distribution in a non-uniformly, weakly ionized gas in the stated fields. This distribution is shown to be in accordance with those previously obtained by Chapman and Cowling (1930, 1939), Margenau [Abstr. 2121 (1946)] and Druyvesteyn (1934) for particular types of applied electric and magnetic fields. The dependence of the distribution on the relationship between the free path and velocity is considered. When the frequency of collision is independent of velocity, the theory leads to a generalization of Langevin's mobility equation. Expressions are obtained for magneto-ionic conductivity, dielectric constant, Hall coefficient and deviation of an electronic beam. Comparison is made with the method of approach based on the calculation of the displacement of an electron by the field during a free path. J. DUTTON

538.561 : 539.11 : 537.12

1484. Theory of plasma waves in metals. P. A. WOLFF. *Phys. Rev.*, **92**, 18–23 (*Oct.* 1, 1953).

See Abstr. 2688 (1952). The Hartree approximation is used to investigate the effect of the crystal lattice on plasma oscillations in metals. The plasma frequency is given by $\omega^2 = 4\pi e^2 n_0 \langle 1/m_z^* \rangle$, where the average is over filled electron states. For free electrons this equation reduces to that given by Bohm and Gross: for insulators $\langle 1/m \rangle_z^* = 0$ and there are no oscillations. In metals with occupied d bands, such as Cu, Ni, and Ag, there is a strong coupling between the plasma wave and the d electrons which

gives rise to frequency broadening. This explains why the plasma lines observed by Ruthemann and Lang [Abstr. 2548, 4029 (1949)] are so much wider in these elements than in Be or Al. Further confirmation of this mechanism could be obtained by repeating their experiments on the transition metals Sc–Ni. A.

538.565 : 537.52 : 621.396.611.4 : 621.317.332.3

1485. Methods of measuring the properties of ionized gases at high frequencies. IV. A null method of measuring the discharge admittance. L. GOULD AND S. C. BROWN. *J. appl. Phys*, **24**, 1053–6 (*Aug.*, 1953).

For Pt III, see Abstr. 8954 (1952). The admittance of a gas discharge may be obtained from measuring the ratio of the transmitted power through a microwave cavity to the incident power as a function of signal frequency near the cavity resonance. The method involves balancing the transmitted and incident signals to zero at the cavity resonance after they have passed through two separate receiving systems. When the signal frequency is changed, an attenuator is used to rebalance the two signals. The change in frequency from resonance and the corresponding change in attenuation gives the necessary data which will plot as a straight line whose slope yields the desired information. A.

538.565 : 537.525.8 : 621.373.42

1486. A wide-range oscillator for use with the mass-spectrometer probe. R. L. F. BOYD AND D. MORRIS. *Electronic Engng*, **25**, 389–90 (*Sept.*, 1953).

The probe described in an earlier paper [Abstr. 3171 (1950)] requires an oscillator giving a const. amplitude output throughout a tuning range of 6–100 Mc/s. In the unit described the wide frequency range is obtained by using resonant-line tuning with the line-length adjustment ganged to the rotor of a capacitor across the open end of the line. The output is held constant by series-valve control of the anode supply voltage. The control signal is obtained by rectification of the output. This can be varied between 1 and 15 V by adjusting the bias on the rectifier.

W. G. STRIPP (R)

538.565 : 621.372.413

1487. Characteristics of an elliptical electromagnetic resonant cavity operating in the TE_{111} mode. T. P. HIGGINS AND A. W. STRAITON. *J. appl. Phys.*, **24**, 1297–9 (*Oct.*, 1953).

Equations and graphs are presented of the resonant wavelength and quality factor of elliptical resonant cavities operating in the TE_{111} mode. Both components of this mode are treated and distinctive characteristics of each are shown as a function of eccentricity of the cavity. A.

538.565 : 621.372.413 : 621.317.763.029.65

1488. Construction and calibration of a cavity-wavemeter for physical measurements. J. C. VAN DEN BOSCH AND F. BRUIN. *Physica*, **19**, 705–18 (*Aug.*, 1953).

The mechanical construction, the calibration and the temperature compensation of a precision cavity-wavemeter for the 12·5 mm range are described. Resonance frequencies calculated from the dimensions have an accuracy of 5 parts in 10^4. After calibration to spectral lines of ammonia this is improved to 1 part in 10^4. For one frequency, readings appear to be reproducible to 1 part in 10^5 between 18 and 25°C. A.

538.566

1489. Optics at the service of microwaves. N. CARRARA. *Nuovo Cimento*, **9**, *Suppl. No.* 3, 251–69 (1952) *In Italian.*

A review of research in the field of microwaves suggested by classical optics, in particular on dispersion in metallic media, on evanescent waves, on the mechanical effects of elliptically polarized waves, on wave propagation in periodic structures and on the application of the Lorentz transformation to the theory of propagation in a waveguide. L. PINCHERLE

538.566

1490. Extension of Fermat's principle to the group propagation time. P. POINCELOT. *C.R.Acad. Sci.* [*Paris*] **237**, 382–4 (*Aug.* 3, 1953) *In French.*

An extension of the author's work on wave propagation in a medium whose refractive index is a function of position [Abstr. 8955 (1952)]. It is shown rigorously that, for any wave train, Fermat's principle can be written in the form $\delta \int_A^B \frac{ds}{Vg} = 0$, where Vg is the group velocity, i.e. the variation of the group propagation time is zero. G. D. SIMS

538.566 : 535.327

1491. Fluctuations of an electromagnetic field due to turbulence, at the extremity of a propagation trajectory within direct visibility. J. VOGE. *C.R. Acad. Sci.* [*Paris*] **237**, 351–3 (*July* 27, 1953) *In French.*

Calculations assuming the Taylor model of turbulence spectrum. Ultra-short waves and light waves are considered separately. G. M. BROWN

538.566 : 537.533.7

1492. Some wave propagation properties of the electron beam in vacuum and in ionized media. O. E. H. RYDBECK. *Nuovo Cimento*, **10**, *Suppl. No.* 2, 101–14 (1953).

The modes which are capable of propagating in an electron beam (space-charge waves) are discussed for the case of a beam moving in a waveguide with a strong axial focusing field. In a longitudinally modulated beam the current obtained near the modulating grid resembles that for a klystron, although the familiar bunching terms do not appear. The analysis is extended to the case of a beam moving in an ionized atmosphere. Although free wave propagation is not normally possible for $\omega_p/\omega > 1$ (ω_p is the plasma frequency of the medium), it is shown that if an electron beam is present, strongly amplified waves can propagate in the beam for all values of ω_p/ω. It is further indicated that as $\omega \to \omega_p$ from below, strong interaction between the beam and the free plasma waves takes place, the plasma waves changing over into space-charge waves when ω_p is exceeded. The importance of this conclusion for solar radio noise outbursts and for the auroral ionosphere is indicated. In conclusion it is shown that the absence of a confining magnetic field allows the propagation of transverse modulated waves on

the beam and also that rapid deceleration of the beam leads to a large increase in the amplification.

G. D. SIMS

538.566 : 621.372.8

1493. Propagation along a slotted cylinder. R. F. HARRINGTON. *J. appl. Phys.*, **24**, 1366–71 (*Nov.*, 1953).

A variational method of determining the attenuation and phase constants for the fields along a slotted waveguide is presented. Calculated and experimental values for a slotted circular waveguide excited in the TE_{11} and TM_{01} modes are included. A.

538.566 : 621.372.8

1494. On the propagation constant in gentle circular bends in rectangular wave guides—matrix theory. A. T. DE HOOP. *J. appl. Phys.*, **24**, 1325–7 (*Oct.*, 1953).

The propagation constant γ_{mn} of the m,nth mode is derived using matrix theory. A.

538.566.2

1495. Effect of a metal plate on total reflection. W. CULSHAW AND D. S. JONES. *Proc. Phys. Soc.* [*London*] *B*, **66**, 859–64 (*Oct.*, 1953).

The phase changes which occur on total reflection are modified when a metal plate is placed near and parallel to a totally reflecting boundary. In particular the phase difference between plane waves of equal amplitude, polarized in and perpendicular to the plane of incidence, can be varied from $-\pi$ through zero and up to the value obtained without the plate. When the refractive index is greater than or equal to $1+\sqrt{2}$, there are two positions of the plate for which the reflected wave is circularly polarized, and in which the electric vector rotates in opposite directions. Measurements of this effect have been made at a wavelength of 1·25 cm, with a microwave analogue of the optical spectrometer, and a 45° Perspex prism with faces 6 in. square. In view of the limitations due to diffraction the results are in good agreement with the theory, and are an elegant way of showing the presence of the evanescent wave beyond a totally reflecting boundary. A.

538.566.2 : 518.42

1496. A microwave computing problem. R. N. BRACEWELL. Note in *Proc. Phys. Soc.* [*London*] *B*, **66**, 987–8 (*Nov.*, 1953).

A drawing-board method of solving the (microwave absorption) equation $\cosh 2\alpha S_1 = A \cosh 2\alpha S_2$ for α when the real numbers S_1, S_2 and A are given.

J. M. C. DUKES

538.566.2

1497. On the propagation of waves in stratified media. F. ABELÈS. *Nuovo Cimento*, **9**, *Suppl. No.* 3, 214–24 (1952) *In French.*

Nine general theorems are enunciated concerning the amplitudes and phases of reflected and transmitted waves at a series of interfaces. Application is made to explain measurements on the troposphere [Abstr. 1948 (1951)] and to correct an error of Gans (1915).

D. H. WHIFFEN

538.566.2 : 523.5

Meteor echo duration and radio wave length. *See Abstr.* 988

538.566.2 : 621.396.11

1498. The propagation of very long radio waves round the earth and signals from lightning. W. O. SCHUMANN. *Nuovo Cimento*, **9**, 1116–38 (*Dec.*, 1952) *In German.*

The theory of the propagation of very long radio waves between the earth and the ionosphere is developed using Sommerfeld's "singular eigenfunctions." Fourier integration is then applied to the formulae for the case of e.m. radiation from lightning discharges of various forms. W. J. G. BEYNON (R)

538.566.3

1499. Influences of ions in the ionosphere. T. SATO. *J. Geomagn. Geoelect.*, **4**, 114–30 (*Dec.*, 1952).

The influence of pos. and neg. ions on the propagation of radiowaves is examined. Especially, these problems are discussed for the wave in and from the lower ionized region where the ionic density is considered to be great. The equation of motion and the Maxwell's equation are solved in the presence of the earth's magnetic field, ionic and electronic collisional frequencies, including the Lorentz polarization term. Results show that (1) influences of the two kinds of ions on the propagation become greater as the frequency of the wave decreases; (2) energy of reflection increases; (3) the deviation of energy and the virtual height of reflection for a wave of a certain frequency become smaller than those in the regions consisting of electrons only; (4) the height of reflection thus approaches to the true height (no retardation), but the magnitude of the electron density, which is given by the relation $N = Af^2$, appears to be doubtful in the case of the measurement by low-frequency radiowaves. A.

538.566.3 : 621.396.11

1500. A tentative method of calculation of h.f. radio sky wave field intensity by use of transmission curve. K. MAEDA, Y. AONO AND T. KOBAYASHI. *Rep. Ionosphere Res. Japan*, **4**, *No.* 2, 61–70 (1950).

Gives the principle underlying the proposed graphical method of calculation of h.f. radio field intensity. A $E_v - f$ curve (field intensity v. frequency at vertical incidence) and an ordinary $h' - f$ curve are needed. Smith's transmission-curve method (1939) is applied and by a deduction of analytical relationships between attenuations at oblique and vertical incidences, it is shown that ambiguity or speculation in the estimation of mean collision frequency and of its distribution can be removed. Some examples and curves are given. A.

538.566.3 : 621.396.11

1501. Field intensity for long distance transmission deduced from the long time measurement. H. UYEDA AND T. OBAYASHI. *Rep. Ionosphere Res. Japan*, **4**, *No.* 2, 71–3 (1950).

A method for calculating field intensity for long transmission circuits is presented and its availability is examined by comparing both calculated and measured daily variations for every month of a year. A.

538.566.3 : 621.396.11

1502. The calculation of the path of a radio-ray in a given ionosphere. A. H. DE VOOGT. *Proc. Inst. Radio Engrs*, **41**, 1183–7 (*Sept.*, 1953).

A third-degree function is presented giving in a hypothetical way the electronic density in the ionosphere as a function of height or distance to the earth

centre: by inserting appropriate values of the constants, in accordance with measured values from ionospheric sounding stations, it is possible to arrive at any desired or proposed form of distribution. This function allows, after substitution, to calculate exactly, i.e. without any approximation, travelling-time, reached maximum height, and reached distance on the earth's surface of a radio-ray radiated at a given angle. The calculation of the ray-path in an ionosphere based on measured values and heights of ionization-maxima at the ionospheric stations and based on arbitrarily selected values of gradients, is thus shown to be possible. A.

538.566.3 : 621.396.11

1503. Some notes on the absorption of radio waves reflected from the ionosphere at oblique incidence. W. J. G. Beynon. *Proc. Instn Elect. Engrs III*, **101**, 15–19 (*Jan.*, 1954).

The results of some oblique-incidence measurements on the ionospheric absorption of radio waves are considered. For both short and very long distances of transmission it is found that there is a marked discrepancy between the observed values and the values calculated from simple theoretical formulae. The contribution of multiple ionospheric reflections to the intensity of the received signal is briefly discussed. A.

538.569 : 538:561 : 537.533.8

Čerenkov effect at microwave frequencies. *See Abstr.* 1395

MAGNETIC EFFECTS 538.6

538.613

1504. Optical contribution to the study of magnetic anisotropy. R. Servant. *J. Phys. Radium*, **14**, 31 S–32 S (*Oct.*, 1953) *In French.*

A brief summary is given of some present-day knowledge appertaining to the Cotton–Mouton and Majorana effects for pure liquids and colloids respectively. H. G. JERRARD

538.632

1505. Sensitive Hall measurements on NaCl and on photoconductive PbTe. J. L. Levy. *Phys. Rev.*, **92**, 215–18 (*Oct.* 15, 1953).

Sensitive Hall equipment was built according to a cross-modulation method with 60 c/s magnetic field, 85 c/s driving current, and 25 c/s selective detection. An attempt was made to measure the Hall effect of ionic conduction in sodium chloride. Theoretically its Hall mobility is expected to be of the order of 10^{-7} m^2/volt-sec (10^{-3} cm^2/volt-sec). However, excessive current noise, of the order of 10 microvolt per c/s, in the sample subjected to electric and magnetic fields of the order of 10^4 volt/m and 1 weber/m^2 at temperatures between 650°c and 800°c, prevented the observation of any Hall signal, yielding only an experimental upper limit of 10^{-7} m^2/volt-sec (10^{-3} cm^2/volt-sec) for the mobility. Measurements of the Hall effect in photoconductive films of lead telluride at 30°c and −190°c are also reported. The results support Simpson's theory that the increase in photoconductivity is primarily due to an increase in carrier density and only secondarily to a change of mobility. A.

538.69 : 532.517

1506. Experiments on magneto-hydrodynamic channel flow. W. Murgatroyd. *Phil. Mag.*, **44**, 1348–54 (*Dec.*, 1953).

Experiments are described in which measurements of pressure gradient were taken during the flow of mercury in a rectangular channel of 15 : 1 aspect ratio, in the presence of a transverse magnetic field. It was possible to suppress turbulence even at the highest obtainable Reynolds number ($R = 10^5$). For high values of R, the friction coefficient C_f appears to be a function of M/R and β. It is suggested that when R is large enough C_f might be a function of the single group $M/R\beta'^{/2}$. This is comparable with the simple relationship proposed by Hartmann and Lazarus (1937). Lundquist [Abstr. 5916 (1952)] has suggested that the transition from laminar to turbulent flow occurs at a fixed value of R/M, and that β does not enter into this criterion. The experiments suggest that the critical condition for the turbulent to laminar transition is $R/M \simeq 900$, although since only one liquid was used, it was not possible to determine the influence of β. A.

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11

1507. The exchange potential in an electron gas at non-zero temperature. N. H. March. Letter in *Phys. Rev.*, **92**, 510 (*Oct.* 15, 1953).

Criticizes and corrects a calculation due to Zirin [Abstr. 5853 (1953)]. Curves are drawn showing the dependence of the exchange energy on temperature for various approximations to the problem and various values of a parameter $\varepsilon_j/\varepsilon_0$. Curves for the free energy are also given. E. P. WOHLFARTH

539.11

1508. Application of the model of the free atom to the metallic atom. T. G. Owe Berg. *J. Phys. Radium*, **14**, 566–70 (*Nov.*, 1953) *In French.*

An application of the concept of the shielding constant for the electrons in free atoms (Slater) to transition metals allows the calculation of the amount of overlap of the 3*d* and 4*s* shells, the number of 3*d* and 4*s* electrons per atom and the cohesive energy of metallic Fe, Co and Ni. E. P. WOHLFARTH

539.11

1509. The electronic structure of some body-centred cubic metals. G. G. Hall. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1162–71 (*Dec.*, 1953).

This is considered using the standard excited state extension of the equivalent orbital method. The form of the energy surfaces for both the standard excited state and the ground state is deduced in terms of a small number of parameters using the trans-

formation properties of a determinant wave function. The energy expressions thus found do not depend on any analytical approximation to the wave functions nor on any arbitrary simplification of the theory. Values of the parameters for lithium and sodium are found by fitting the theoretical energies to energies calculated by other methods. A.

539.11 : 530.162 : 537.12

Electron interaction in metals. *See Abstr.* 1279

539.11 : 536.212

The influence of exchange forces on the thermal conductivity of metals. *See Abstr.* 1234

539.11 : 537.12

1510. A modified theory of production of secondary electrons in solids. A. VAN DER ZIEL. *Phys. Rev.*, **92**, 35–9 (*Oct.* 1, 1953).

A few difficulties in the previous theories of energy loss and secondary electron production by primary electrons in metals can be removed by replacing the Coulomb interaction between a primary electron and a lattice electron by a screened Coulomb interaction, such as required by the plasma theory. In the new theory Wooldridge's mechanism of secondary electron production seems to have lost most of its importance. The energy loss distribution due to the interaction with the conduction electrons of the metal is found to have a maximum at an energy loss slightly less than $(\hbar^2/k_m^2/2m)$, where k_m is the value of the wave vector of the conduction electrons at the Fermi level. The theory is also applied to the bound electrons, and it is shown that the screened Coulomb interaction does not change the previous results very strongly. It is also shown that the polarization of the medium has only a small influence upon the previous results for insulators. A.

539.11 : 548.7

1511. Polarization forces in [ionic] crystals. A. HERPIN. *J. Phys. Radium*, **14**, 611–20 (*Nov.*, 1953) *In French.*

Theoretical study of new interionic forces which account for small deviations in ionic crystals from the Cauchy relation between elastic constants, $C_{12} = C_{44}$. The polarization forces are caused by interaction of an ion, polarized by the crystal field, as modified by ionic displacements, with other ions, and involves the ions at least in threes. The interaction energy due to the dipole and quadrupole parts of these forces is derived as an expansion in powers of the displacements. For C lattices (each ion a centre of symmetry), the dipole part has no effect on equilibrium energy or static elastic constants. For cubic C lattices the first term due to the quadrupole part is the second power, giving the elastic constants. An approximate calculation of C_{12}–C_{44} for alkali halides gives good agreement with experiment. J. HAWGOOD

539.11 : 548.7

1512. A variation principle for electronic wave functions in crystals. D. P. JENKINS AND L. PINCHERLE. *Phil. Mag.*, **45**, 93–9 (*Jan.*, 1954).

A variation principle giving the energy levels of electrons in polyatomic lattices is presented. When used in conjunction with the cellular method it includes the matching of the wave functions across cell boundaries without the need of making *ad hoc* assumptions. Values of $\nabla_{\mathbf{k}}E(\mathbf{k})$ can be obtained from quantities used to determine $E(\mathbf{k})$ without carrying out any numerical differentiation. The results of some calculations on the valency bands of lead sulphide are reported. A.

539.11 : 548.7 : 539.32

1513. On the elastic constants of cubic ionic crystals. S. O. LUNDQVIST. *Ark. Fys.*, **6**, *Paper* 3, 25–38 (1952).

The elastic constants C_{12} and C_{44} of cubic ionic crystals with ions having complete electron shells are investigated, starting from the expression for the cohesive energy in the Heitler–London approximation. It is found that $(C_{44} - C_{12})$ is a function not only of the interionic distance and the overlapping but also of the relative size of the ions. For crystals with positive and negative ions of about the same size the deviations from the Cauchy relations must be expected to be very small. A new method of calculating C_{12} and C_{44} is developed and numerical applications have been carried out for NaCl. A.

MOLECULAR STRUCTURE 539.13

539.13

1514. Exchange between rotational and translational energy in gas molecules. J. C. BECKERLE. *J. chem. Phys.*, **21**, 2034–41 (*Nov.*, 1953).

Rotational relaxation times for the gases H_2 and D_2 have been calculated with the quantum mechanical method of distorted waves using a one-dimensional collision model and an exponential repulsive interaction potential. The potential constants were determined by fitting to the data of Hirschfelder *et al.* and certain theoretical potential calculations for H_2 by Margenau. The calculations indicate that more than one relaxation time is required to describe rotational relaxation phenomena in these gases. The theoretical relaxation times are 15 to 35 times shorter than the experimental values when one averages with the velocity distribution for a Maxwellian beam of particles. The relative values of the calculated relaxation times compare favourably with those obtained from experiments. Averaging with a one-dimensional velocity distribution instead of that of a Maxellian beam of particles at temperature T yields calculated values of the relaxation times that are a factor 7 to 19 shorter than the experimental values. One expects the calculated values to be shorter than the experimental values in view of the one-dimensional collision model. The method used in treating H_2 collisions is not applicable to N_2 and O_2. Results of another approximation method for these gases indicate that more complicated techniques must be used. A.

539.13 : 530.145

1515. The quantum mechanics of collisions between diatomic molecules. C. F. CURTISS. *J. chem. Phys.*, **21**, 2045–50 (*Nov.*, 1953).

Explicit expressions for the angular transition probabilities are obtained. These expressions are in terms of a set of coefficients which are defined by the asymptotic form of the solutions of a set of coupled

differential equations in one variable, the separation of the molecules. The coupled differential equations involve integrals of the intermolecular potential function, which may be of any form. A solution of the coupled differential equations by a perturbation method, which is valid in the case of low-energy collisions, in which transitions occur rarely, is discussed. A.

539.13 : 539.15

1516. On the localizability of particles in nuclei and electron shells of atoms and molecules. R. DAUDEL. *C.R. Acad. Sci.* [*Paris*] **237,** 601–3 (*Sept.* 21, 1953) *In French.*

The concept of localized wave functions enables one to divide the space of atoms and molecules into small fixed volumes containing more often than not an α electron, a β electron or an α and β electron together. Similarly the space of nuclei may be divided into small fixed volumes containing an α or β proton, an α or β neutron or an assembly of these categories. The best representation of this kind for atoms is that of the Pauling hybrid orbitals, for molecules that of the equivalent orbitals of Lennard Jones whilst the nuclear case is comparable to the atom problem. H. H. GREENWOOD

539.132

1517. Force constants of certain diatomic molecules. Y. P. VARSHNI. Letter in *Curr. Sci.*, **22,** 199–200 (*July*, 1953).

See also Abstr. 7157 (1951). Some examples are listed illustrating Walsh's rule, that the ratio of the force constants of two molecules, one consisting of an element of the C group and an element of the O group, the other consisting of the same C group element and a F group element with atomic number one unit higher than that of the O group element (e.g. CO and CF), is constant. This ratio varies for the different C group elements. These data can be used for the prediction of force constants. A. J. TAYLOR

539.132 : 536.66

1518. The heat of sublimation of tin and the dissociation energy of SnO. L. BREWER AND R. F. PORTER. *J. chem. Phys.*, **21,** 2012–13 (*Nov.*, 1953).

The heat of sublimation of tin has been redetermined and found to be 70 $\pm$ 2 kcal/mole. This value combined with the heat of formation of gaseous SnO agrees with the linear Birge–Sponer extrapolation to the ground-state atoms. A.

539.132 : 536.66

1519. Calculation of the heats of formation of gaseous free radicals and ions. J. L. FRANKLIN. *J. chem. Phys.*, **21,** 2029–33 (*Nov.*, 1953).

A simple method of calculating the heats of formation of gaseous free radicals and carbonium ions is presented, and a number of examples are given which show good agreement of calculated values with experiment. It is shown that the method permits ready calculation of bond strengths, including the strength of bonds in alicyclics, and the ionization potential of olefins, aromatics, and other unsaturates. The method is not directly applicable to the calculation of the ionization potentials of saturates. A.

539.132

1520. Potential function for the vibrations of $H_2C = CBr_2$, $HDC = CBr_2$, $D_2C = CBr_2$. C. MANNEBACK AND A. RAHMAN. *Ann. Soc. Sci. Bruxelles*, **67,** 140–76 (*June*, 1953).

The problem of the plane vibrations of these molecules was investigated, using a new mathematical technique which may be applied to complicated molecules for which a complete solution is impracticable. The calculation is not based on the assumption of a certain type of potential function for the molecule but simplifying assumptions are made during the course of the calculation itself, the only restrictions imposed being those which the problem allows. Successive iteration enables the determination of a rough potential function and repetition of the process brings about convergence to yield, eventually, an accurate solution. If the reiteration does not converge, drastic changes in the initial assumptions are necessary. The potential function calculated by means of the observed frequencies of $H_2C = CBr_2$ and $D_2C = CBr_2$ has been used to calculate the frequencies of $HDC = CBr_2$ and the agreement with the observed frequencies for this compound is excellent. G. I. W. LLEWELYN

539.132

1521. Importance of $\nu_{11}e_{12}(849)$ vibration of benzene in determining the structure of monosubstituted benzenes. S. N. GARG. Letter in *J. chem. Phys.*, **21,** 1907 (*Oct.*, 1953).

If the frequency 800–849 cm^{-1} of a substituted benzene seems to belong to totally symmetric species on account of low Raman depolarization factor and/or the analysis of u.v. spectrum, the molecule should possess either C_2 symmetry or no symmetry. G. I. W. LLEWELYN

539.132

1522. Assignment of the O–H deformation frequency. J. R. QUINAN AND S. E. WIBERLEY. Letter in *J. chem. Phys.*, **21,** 1896–7 (*Oct.*, 1953).

From Raman and infrared measurements on nine aliphatic alcohols and the corresponding deuterated compounds, the O–H deformation frequency is identified at 1020 cm^{-1}. G. I. W. LLEWELYN

539.132

1523. The ground-state vibration frequencies of molecules of the type XX. Y. P. VARSHNI. *Z. Phys.*, **135,** *No.* 5, 512–15 (1953) *In German.*

The vibration frequency, ω_e, varies approximately with ionization potential, V, as follows: $\log \omega_e = g - h \log n^2 V$, where n is the principal quantum number of the valency electron, and g and h are constants which vary from group to group. R. F. BARROW

539.132

1524. The mean amplitudes of thermal vibrations in polyatomic molecules. II. An approximate method for calculating mean square amplitudes. Y. MORINO, K. KUCHITSU, A. TAKAHASHI AND K. MAEDA. *J. chem. Phys.*, **21,** 1927–33 (*Nov.*, 1953).

For Pt I, see Abstr. 5224 (1952). A simple method of the calculation of the mean amplitudes of both directly bonded atom pairs and non-bonded ones is proposed by approximating the function $\coth x$ by $1/x + x/4$. The enumeration of the **L** matrix, the most time-consuming procedure, is replaced by the calculation of the inverse matrix $\mathbf{F}^{-1}$ from the poten-

tial energy matrix. The formulae obtained are applicable with reasonable accuracy (4%) to almost all the cases except the atom pairs having higher frequencies than 1200 cm^{-1}. For the latter cases modified formulae are presented by using hyperbolic cotangent function. It is also revealed that, if some allowance be made for the errors of the mean amplitudes, a definite value can be assigned to the mean amplitude of a given pair of atoms, without referring to the structure of the other part of the molecule. Reliable values of the mean amplitudes are computed for some typical atom pairs, by the use of the force constants of Urey–Bradley type obtained by the analysis of the vibrational spectra. A.

539.132

1525. Vibrational transition probabilities of diatomic molecules. I. P. A. Fraser and W. R. Jarmain. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1145–52 (*Dec.*, 1953).

An approximation is made which allows analytic integration of the "overlap," and other, integrals of vibrational wave functions in Morse potentials that arise in the study of the electronic spectra of diatomic molecules. The heavy and lengthy work that goes into numerical integration is thus avoided for many bands of many systems. The necessity for the type of approximation made is discussed from the point of view of the extensive cancellation that occurs in any method of evaluating these integrals. An indication is given of the validity and applicability of the approximation and the formulae thus derived. In this paper *p*-values (i.e. overlaps squared) calculated on this approximation are presented for the transitions N_2, $B^3\Pi_g \rightarrow A^3\Sigma_u^+$ (First Positive) and N_2, $C^3\Pi_u \rightarrow B^3\Pi_g$ (Second Positive), and compared with values calculated with Morse wave functions by numerical methods. The agreement is excellent. A.

539.132

1526. Vibrational transition probabilities of diatomic molecules. II. W. R. Jarmain and P. A. Fraser. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1153–7 (*Dec.*, 1953).

Two improvements in the method of calculating vibrational overlap integrals (see preceding Abstr.) are given. The first improvement allows the treatment of cases where $|(\alpha_1 - \alpha_2)/(\alpha_1 + \alpha_2)|$ is so large ($\gtrsim 5\%$) that the results using the previous technique are merely indicative of trends. α_1 and α_2 are the parameters in the Morse potentials whose adjustment is the basis of the approximation in Pt I. The second improvement is a method of overcoming algebraically the heavy cancellation (intrinsic in the wave functions) that limits the extent of tables of *p*-values (i.e. overlaps squared). Formulae for the 0, 1, 2 and 3 progressions in either direction are given that allow the overlaps to be calculated for much higher quantum numbers than was previously possible. A.

539.132 : 535.338.4

Analysis of the vibration-rotation spectrum of OH. *See Abstr.* 1161

539.132 : 535.343–14

Microwave spectra of CsF, CsCl, and CsBr. *See Abstr.* 1164

539.132 : 535.343.4

Molecular constants of CHD_3. *See Abstr.* 1172

539.132 : 535.343.4–15

The infrared spectra of the methyl chlorosilanes. *See Abstr.* 1179

539.132

1527. Molecular beam investigation of rotational transitions. I. The rotational levels of KCl and their hyperfine structure. C. A. Lee, B. P. Fabricand, R. O. Carlson and I. I. Rabi. *Phys. Rev.*, **91**, 1395–403 (*Sept.* 15, 1953).

The molecular beam electrical resonance method, which has heretofore been confined to the study of transitions between the $m = 0$ and $m = \pm 1$ states of diatomic polar molecules in the state $J = 1$, has been extended to the study of rotational transitions from $J = 0$ to $J = 1$. The inhomogeneous electric fields together with a stop wire are so arranged that molecules in the state $J = 0$ are selectively refocused on the detector. A transition to the state $J = 1$, under the influence of the applied r.f. field, is observed by a reduction in beam intensity at the detector. The spectra obtained in this way yield more information than with the older method. The hyperfine structure of the state $J = 1$ of the molecules $K^{39}Cl^{35}$, $K^{39}Cl^{37}$, and $K^{41}Cl^{35}$ has been investigated at zero field for several vibrational states, and molecular constants obtained. The structure of the $J = 1$ state was attributable to a nuclear quadrupole interaction for each nucleus. The ratios of the quadrupole moments of the potassium isotopes is $Q_K^{41}/Q_K^{39} = 1{\cdot}220 \pm 0{\cdot}002$. From observation of line shifts in a weak electric field, the molecular dipole moment was determined in two vibrational states. For $v = 0$, $\mu = 10{\cdot}48 \pm 0{\cdot}05$ Debye, and for $v = 2$, $\mu = 10{\cdot}69 \pm 0{\cdot}05$ Debye. The ratio of the dipole moments is $1{\cdot}020 \pm 0{\cdot}004$. The mass ratios of the Cl and K isotopes calculated from the molecular constants are $Cl^{35}/Cl^{37} = 0{\cdot}9459803 \pm 0{\cdot}0000015$ and $K^{39}/K^{41} = 0{\cdot}9512189 \pm 0{\cdot}0000015$. A.

539.132

1528. Molecular beam investigation of rotational transitions. II. The rotational levels of KBr and their hyperfine structure. B. P. Fabricand, R. O. Carlson, C. A. Lee and I. I. Rabi. *Phys. Rev.*, **91**, 1403–8 (*Sept.* 15, 1953).

The molecular beam electrical resonance method has been used to study the hyperfine structure of the first rotational state in $K^{39}Br^{79}$ and $K^{39}Br^{81}$. The hyperfine structure arises from the splitting of the $J = 1$ state into 10 levels by the quadrupole interactions of potassium and bromine. Molecules in the $J = 0$ rotational state were refocused, and transitions to the $J = 1$ state were observed by a decrease in beam intensity at the surface ionization detector. From the structure of the line resulting from the transition $J = 0 \rightarrow J = 1$ in the three lowest vibrational states. The molecular constants were obtained, including the quadrupole interactions and dipole moments in $K^{39}Br^{79}$ in the $v = 0$, 1, 2 vibrational states. The quadrupole interactions in the $v = 0$ state of $K^{31}Br^{81}$ are $(eqQ)_K = -5{\cdot}002 \pm 0{\cdot}003$ and $(eqQ)_{Br} = 8{\cdot}555 \pm 0{\cdot}006$ Mc/s. The mass ratio of the bromine isotopes is $M_{Br}^{79}/M_{Br}^{81} = 0{\cdot}9753088 \pm 0{\cdot}0000020$. The ratio of the bromine quadrupole moments is $Q_{Br}^{79}/Q_{Br}^{81} = 1{\cdot}1973 \pm 0{\cdot}0006$. A.

539.132

1529. Wave functions of the hydrogen molecular ion. D. R. Bates, K. Ledsham and A. L. Stewart. *Phil. Trans A*, **246**, *No.* 911, 215–40 (1953).

The $1s\sigma_g$, $2s\sigma_g$, $3s\sigma_g$, $2p\sigma_u$, $3p\sigma_u$, $4p\sigma_u$, $3d\sigma_g$, $4f\sigma_u$, $2p\pi_u$ and $3d\pi_g$ states of the hydrogen molecular ion are investigated. The main results are given in the form of tables of parameters from which the electronic wave functions (in spheroidal co-ordinates) can be obtained. A representative selection of contour diagrams is also presented. A.

539.132

1530. Properties of the hydrogen molecular ion. II. Photo-ionization from the $1s\sigma_g$, $2s\sigma_g$ and $3s\sigma_g$ states. D. R. Bates, U. Öpik and G. Poots. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1113–23 (*Dec.*, 1953).

For Pt I, see Abstr. 8619 (1953). The cross-sections associated with transitions from the bound $1s\sigma_g$, $2s\sigma_g$ and $3s\sigma_g$ states of H_2^+ to the free $p\sigma_u$, $p\pi_u$, $f\sigma_u$ and $f\pi_u$ states are calculated using exact two-centre electronic wave functions. They are tabulated for various values of the energy of the ejected electron and of the distance between the protons (which are treated as fixed in position). In the case of the $1s\sigma_g$ state (which, alone of the three, is stable) the investigation is carried farther: the vibration and rotation of the molecule are taken into account and curves showing true photo-ionization cross-section plotted against wave number are obtained. A.

539.132

1531. Properties of the hydrogen molecular ion. III. Oscillator strengths of the $1s\sigma_g$–$2p\pi_u$, $2p\sigma_u$–$3d\pi_g$ and $2p\pi_u$–$3d\pi_g$ transitions. D. R. Bates, R. T. S. Darling, S. C. Hawe and A. L. Stewart. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1124–8 (*Dec.*, 1953).

The oscillator strengths of these transitions of H_2^+ are calculated from the exact two-centre wave functions. A comparison is made with results obtained from the LCAO approximation, both the dipole length and the dipole velocity formulae being used. The polarizability of the normal ion perpendicular to the molecular axis is discussed briefly. A.

539.132

1532. Electronic states of diatomic molecules: The oxygen molecule. F. G. Fumi and R. G. Parr. *J. chem. Phys.*, **21**, 1864–8 (*Oct.*, 1953).

A scheme is proposed for the computation of electronic energy levels of diatomic molecules with fair accuracy and minimum labour. The theoretical LCAO MO method including configuration interaction is employed. However, the number of configurations considered is kept small; the energies of the asymptotic dissociation products for the various states are taken from atomic data in the manner of Pariser; the calculation of the interaction energies is simplified by the neglect of overlap in all terms and by the neglect of differential overlap in the electronic repulsion terms; and certain core parameters are fitted empirically. The first application is made to the oxygen molecule, using one empirical parameter. The vertical excitation energies from the ground state to the $^1\Delta_g$, $^1\Sigma_g^+$, $^3\Sigma_u^+$ and $^3\Sigma_u^-$ states are computed as functions of distance between 1·16 Å and 1·63 Å, and they agree with the observed values within 0·2 eV; excitation energies to the unobserved $^1\Sigma_u^-$, $^3\Delta_u$, $^1\Delta_u$ and $^1\Sigma_u^+$ states are also computed. The results are in substantial accord with a previous more involved calculation by Moffitt. A justification of the proposed scheme is presented which makes use of the orthonormalized atomic orbitals of Löwdin. A.

539.132

1533. Quadrupole coupling of the deuteron in DCCCl and DCN. R. L. White. Letter in *Phys. Rev.*, **91**, 1014 (*Aug.* 15, 1953).

The $J = 1 \rightarrow 2$ transition of DCCCl has been studied with a high resolution bridge spectrometer. It was deduced from the $F_1 = \frac{1}{2} \rightarrow \frac{1}{2}$ and $F_1 = \frac{3}{2} \rightarrow \frac{3}{2}$ transitions ($F_1 = J + I_{Cl}$) that $(eqQ)_D = +175 \pm 20$ kc/s. This gives a higher precision than similar data deduced from the broadening of lines on HCN and DCN. H. H. GREENWOOD

539.132

1534. Bond moments and derivatives in CF_4, SiF_4, and SF_6 from infrared intensities. P. N. Schatz and D. F. Hornig. *J. chem. Phys.*, **21**, 1516–30 (*Sept.*, 1953).

The absolute intensities of the fundamental infrared absorption bands of SiF_4, CF_4 and SF_6 were measured utilizing the pressure-broadening technique. The effective bond moments, μ_0, and bond moment derivates, $\partial u/\partial r$, are calculated as a function of the most general potential constants. Based on a valence force field plus repulsion between non-bonded atoms, the most probable values and the alternatives are quoted and discussed. A.

539.132

1535. On the definition and properties of localized orbitals. H. Brion and R. Daudel. *C.R. Acad. Sci.* [*Paris*] **237**, 567–9 (*Sept.* 14, 1953) *In French.*

The correlation between orbital maxima and most probable configuration is enhanced if the orbitals are more localized, as has been shown to hold for equivalent orbitals. The most localized orbitals correspond to a minimum exchange energy. This definition remains valid even when equivalent orbitals cannot be defined owing to lack of symmetry. J. JACOBS

539.132

1536. Does carbon utilize 3*d* orbitals in bonding? H. H. Jaffé. Letter in *J. chem. Phys.*, **21**, 1893 (*Oct.*, 1953).

A criticism of the work of Gillespie [Abstr. 5233 (1952)] indicating the use of 3*d* orbitals in carbon bonding. The comparison used by Gillespie with S and P bonding is considered invalid since electron shifts from the central atom which stabilize the 3*d* bonding are not found in C bonding to the same extent. The substantial overlap of Gillespie's *spd* hybrid orbitals is based on their angular dependence. Calculations of the overlap integral using Slater's formula for the effective nuclear charge (Z_{eff}) give the value zero since Z_{eff} is zero. No reasonable value for Z_{eff} would give appreciable overlap. It is concluded that 3*d* orbitals are not of importance in C bonding. H. H. GREENWOOD

539.132

1537. The use of 3*d* orbitals in bonding by carbon. R. J. GILLESPIE. Letter in *J. chem. Phys.*, **21**, 1893–4 (*Oct.*, 1953).

A reply to Jaffé's criticisms (see preceding abstract). It is pointed out that Gillespie suggested that carbon may use its 3*d* orbitals only in bonding with strongly electronegative elements in agreement with Jaffé's criticism. The zero Z_{eff} obtained by use of Slater's rules applies to C^-. The value $Z_{eff} = 1$ is obtained for the neutral carbon atom of the problems under discussion. The estimation of a reasonable value for Z_{eff} is difficult, but there appears to be little justification for supposing the 3*d* overlap to be small and their contribution to bonding therefore negligible.

H. H. GREENWOOD

539.132

1538. Eigenfunctions of S_2 by a spin operator method. G. W. PRATT, JR. *Phys. Rev.*, **92**, 278–88 (*Oct.* 15, 1953).

An operator is derived which is a function of step-up and step-down operators pertaining to spin angular momentum, and which creates a state of definite multiplicity when operating on a single determinant of spatial and spin orbitals. This paper is concerned with the problem of finding all of the orthogonal singlets for a 2*N*-electron system in terms of the spin operator. The five orthogonal singlets corresponding to the six-electron spin degeneracy problem are studied in detail by means of the branching diagram. The fourteen orthogonal singlets corresponding to the eight-electron problem and the forty-two orthogonal singlets corresponding to the ten-electron problem are written down. Some remarks are made concerning the application of this method to a configuration interaction investigation. A.

539.132

1539. Ground and excited electronic states and molecular vibrations of some polyatomic molecules. J. DUCHESNE AND L. BURNELLE. *J. chem. Phys.*, **21**, 2005–8 (*Nov.*, 1953).

The vibration potential functions of electronic ground and excited states of molecules of C_{2v} and D_{6h} symmetry are computed and compared. From this, quantitative characteristics of the molecular orbitals belonging to the correlated angular molecules and to a negative ion are deduced and, in this connection, the structure of the CF_2 and CH_2 radicals is discussed. The behaviour of the interaction terms is examined, and a rule concerned with their sign is obtained in the case of $n \rightarrow \pi^*$ and $\pi \rightarrow \pi^*$ transitions. Various other effects, such as the $\sigma - \pi$ resonance and the part played by the lone-pair electrons, are studied. A.

539.133 : 538.224 : 541.67

1540. Magnetic properties and structure of molecules. Contribution to the study of the delocalization of electrons. A. PACAULT, N. LUMBROSO AND J. HOARAU. *Cahiers de Phys.*, *No.* 43, 54–71 (*May*, 1953) *In French.*

The systematics correlating diamagnetism and molecular structure are reviewed by consideration of recent experimental evidence. The diamagnetic anisotropies of a large number of aromatic compounds are recorded but in order to elucidate the extent of delocalization of electrons in these substances, a knowledge of the variation of anisotropy with temperature is necessary—results obtained for this variation are too few to be conclusive. Details of the experimental arrangement for the measurement of the magnetic anisotropy are given.

G. I. W. LLEWELYN

539.133 : 548.736.3

1541. The crystal and molecular structure of tetraborane. C. E. NORDMAN AND W. N. LIPSCOMB. *J. chem. Phys.*, **21**, 1856–64 (*Oct.*, 1953).

The molecular structure of B_4H_{10} has been determined from 616 observed reflections from single crystals. The ordered phase is monoclinic $P2_1/n$, with four molecules in a unit cell with parameters, $a = 8{\cdot}68$, $b = 10{\cdot}14$, $c = 5{\cdot}78$ Å and $\beta = 105{\cdot}9°$. Complete three-dimensional Fourier syntheses, including one from which the boron atoms had been subtracted, were employed to locate unambiguously the positions of all atoms. Molecular dimensions indicate that the isolated molecule has symmetry C_{2v}. The boron atoms form two triangles $B_IB_IB_{II}$ with a common edge $B_I - B_I$ the angle between the planes of the triangles being 118·1°. Each of the two B_I borons has one attached hydrogen atom, and each B_{II} has two attached hydrogen atoms. The remaining four hydrogen atoms form bridges between the four $B_I - B_{II}$ pairs. Molecular parameters are four $B_I - B_{II} = 1{\cdot}845 \pm 0{\cdot}002$ Å, $B_I - B_I = 1{\cdot}750$ Å, $B_{II} - B_{II} = 2{\cdot}786$ Å, six $B - H = 1{\cdot}11 \pm 0{\cdot}04$ Å, four $B_I - H$ (bridge) $= 1{\cdot}21 \pm 0{\cdot}03$ Å and four $B_{II} - H$ (bridge) $= 1{\cdot}37 \pm 0{\cdot}10$ Å. Mean values and their average deviations have been given on the assumptions that the molecular symmetry is C_{2v} and that the six B — H distances are equal. There is an interesting false, incorrect structure which almost satisfies the X-ray diffraction data. A metastable modification, obtained by sudden freezing of the super-cooled liquid, has spherically disordered molecules in hexagonal close packing. There are two molecules in a unit cell of dimensions, $a = 5{\cdot}79$ and $c = 9{\cdot}36$ Å. A.

539.133

1542. Mean dimensions of rubber-like polymer molecules. F. T. WALL. *J. chem. Phys.*, **21**, 1914–19 (*Nov.*, 1953).

The mean square end-to-end separations of coiling type polymer molecules have been calculated by two different approximate methods, taking into account the effect of excluded volumes. One of the methods is the equivalent of a first-order perturbation calculation using the unrestricted random walk as a starting approximation. The other method involves the use of certain plausible functional forms valid for large values of the chain lengths. The calculations have been carried out for three, two and one dimensions and the results are analysed to provide an insight into factors which might determine convergence or divergence of the quotient $\langle r_n^2 \rangle_{Av}/n$ (the mean-square length divided by the number of links). It appears that the quotient converges in three (or more) dimensions, but diverges for a lower number of dimensions. A.

ATOMIC STRUCTURE . NUCLEUS ISOTOPES 539.15

539.152.1

1543. Birmingham nuclear physics conference. J. K. BELING. *Nucleonics*, **11**, 32–5 (*Oct.*, 1953).

Short summaries of papers presented at a conference held during July 13th–18th are given. The topics reported include: experimental evidence in support of the Bohr and Mottelson quasi-molecular model of the nucleus; results of experiments on the nuclear scattering of high-energy electrons; observations of polarization in proton-proton scattering; present status of meson theory of nuclear forces.

L. R. SHEPHERD

539.152.1

1544. The annual review of nuclear science. II. *Stanford: Annual Reviews; London: H. K. Lewis* (1953) ix + 429 *pp.*

Review in *Proc. Phys. Soc.* [*London*] *A*, **66**, 1198–9 (*Dec.*, 1953). Subjects covered include origin and abundance of elements; energy production in stars; origin and propagation of cosmic rays; production and distribution of radiocarbon (excluding results of archeological dating); subnuclear particles; recent progress in accelerators; nuclear reactions induced by high-energy particles; recent studies of photonuclear reactions; advances in nucleon-nucleon scattering experiments and their theoretical consequences; angular correlation of nuclear radiation; nuclear moments; experimental clarification of the theory of β-decay; β-decay energetics; radiation effects in solids; isotopic masses and abundances, and isotope effects on phase equilibria and on chemical kinetics; high-energy fission.

539.152.1

1545. On the shell structure of nuclei. II. G. SZAMOSI. Note in *Naturwissenschaften*, **40**, *No.* 16, 433 (1953) *In German.*

For Pt I, see Abstr. 6178 (1953). Single particle levels calculated in a well generated by a Gaussian density distribution of sources of a Yukawa potential with spin-orbit coupling. They do not lead to the observed shells.

W. J. SWIATECKI

539.152.1

1546. Theoretical studies in nuclear structure. IV. Wave functions for the nuclear *p*-shell. B. $\langle p^n|p^{n-2}p^2\rangle$ fractional parentage coefficients. J. P. ELLIOTT, J. HOPE AND H. A. JAHN. *Phil. Trans A*, **246**, *No.* 912, 241–79 (1953).

The totally antisymmetric states for the *p*-shell nuclei previously given [Pt IVA, Abstr. 1162 (1952)] are transformed into the form of linear combinations of antisymmetric states for $n-2$ particles vector-coupled to antisymmetric states of particles n and $n-1$. The coefficients of the combinations, the $\langle n|n-2,2\rangle$ fractional parentage coefficients, are shown to be products of weight factors, orbital factors and charge-spin factors which are tabulated separately, the tabulation being simplified by use of the special unitary group. This form of the wave functions is the most suitable for the evaluation of any two-body interaction and has been used in a series of investigations (J. P. Elliott 1952, 1953; Robinson 1953) relating to the effect of tensor and spin-orbit forces on the levels of *p*-shell nuclei. The complete *p*-shell charge-symmetric central force matrix given by Racah (1950) with unspecified phases is recalculated with the standard (amended) phases of Pt IVA, with the help of the coefficients here tabulated.

A.

539.152.1

1547. The *J* values of states in configurations $(j)^n$. G. E. TAUBER AND T.-Y. WU. Letter in *Nuovo Cimento*, **10**, 677–80 (*May*, 1953).

A straightforward method is given for finding the allowed values of J for all configurations $(j)^n$ (j = half integral angular momentum, n = number of identical particles) and the number of levels for each value of J. Tables for j up to 11/2 and all n. [See also Abstr. 2919 (1951), 4529 (1952)].

W. J. SWIATECKI

539.152.1

1548. Equal ratios of energies of nuclear excited states of even-even isotopes. M. G. REDLICH. *Proc. Nat. Acad. Sci. U.S.A.*, **39**, 560–3 (*June*, 1953).

In 6 out of 9 pairs of isotopes the addition of 2 or 4 neutrons does not alter the ratio between the energies of the 1st and 2nd excited states.

W. J. SWIATECKI

539.152.1

1549. Note on the saturation properties of nuclear forces. S. ENDO AND H. KANAZAWA. Letter in *Progr. theor. Phys.*, **8**, 252–3 (*Aug.*, 1952).

The explanation of saturation properties, on the basis of a difference in mass between free mesons and those in a heavy nucleus, is extended. It is shown for charge-independent and charge-symmetric nuclear potentials that spin-parallel nuclei and neutron clusters are unstable or at most metastable.

G. FIELD

539.152.1

1550. Studies in intermediate coupling: the energy states of ^{13}C and ^{13}N belonging to the configuration $1p^9$. A. M. LANE. *Proc. Phys. Soc.* [*London*] *A*, **66**, 977–94 (*Nov.*, 1953).

The nuclear shell-model and the theory of fractional parentage are used to derive theoretical formulae for certain observable features of nuclear energy levels that are not expected to be sensitive to the choice of the nucleon interaction potential. These features comprise: (i) the magnetic dipole transition strengths, (ii) the magnetic moments, (iii) the reduced widths for nucleon emission. Intermediate coupling, besides extreme L–S and extreme j–j coupling, is discussed, and the resulting formulae are applied to the low-lying odd-party states of C^{13} and N^{13} in an attempt to explain all the relevant experimental data. It is found that the extreme coupling models give generally poor agreement of theory with experiment. On the other hand, all the data are consistent with an intermediate coupling model and quite a small range of values of the intermediate coupling parameter.

A.

539.152.1

1551. Intermediate coupling and nuclear reactions. A. M. LANE. Letter in *Phys. Rev.*, **92**, 839 (*Nov.* 1, 1953).

The reduced widths for nucleon emission and the matrix elements of electromagnetic transitions are calculated for light nuclei, using the shell model, the

theory of fractional parentage and for either L–S or j–j coupling. Comparison with experiment strongly suggests intermediate coupling. P. T. MATTHEWS

539.152.1

1552. Nuclear radii. F. BITTER AND H. FESHBACH. Letter in *Phys. Rev.*, **92**, 837 (*Nov.* 1, 1953).

Some nuclear radii are estimated from high-energy electron scattering experiments and shown to be consistent with isotope shift data, with the semi-empirical mass formula [Abstr. 7033 (1953)] and may be reconciled with evidence from the Coulomb energy difference in light nuclei. These radii are considerably smaller than those usually quoted.

P. T. MATTHEWS

539.152.1

1553. Isotopic spin selection rules. IV. Radiations from ^{20}Ne. D. H. WILKINSON AND A. B. CLEGG. *Phil. Mag.*, **44**, 1322–5 (*Dec.*, 1953).

For Pt III, see Abstr. 690 (1954). The possibility is considered that the 13·70 MeV (2−) state of Ne^{20} is $T = 0$ in which case the electric dipole transition to the 1·63 MeV (2+) state of Ne^{20} is forbidden by the isotopic spin rule. This transition is sought and is shown to have a radiative width of less than 2 eV corresponding to a $(2J + 1)|M|^2$ value of less than 0·007. From this we may deduce that the contamination of this state with $T = 1$ is less than 3% in intensity if we neglect the possible diminution of the transition matrix element due to the high level density. A.

539.152.1

1554. Nuclear surface oscillations. A. K. KERMAN. *Phys. Rev.*, **92**, 1176–83 (*Dec.* 1, 1953).

The extreme shell model of the nucleus is extended by allowing the last odd nucleon to interact with collective modes of motion of the even-even nuclear core. The interaction between a nucleon and the surface oscillations of the core was given by Bohr and is employed here with a Fock space representation for the core excitation. Because of the interaction neither the nucleon nor the core conserve their angular momentum, but the total angular momentum is conserved. The problem is treated by the Tamm–Dancoff method. In terms of the Tamm–Dancoff wave function, formulae are derived for the magnetic moment and the quadrupole moment of an odd nucleus. The energy of excitation of the core is taken empirically from the first excited state of the corresponding even-even nucleus. With this procedure all the parameters of the theory are fixed. The magnetic moment deviations calculated in this manner agree with experiment for nuclei in which the total angular momentum is one-half, but the agreement does not exist for higher angular momenta. It is also possible to obtain a qualitative fit for the large quadrupole moments of nuclei with odd numbers of nucleons between fifty and eighty-two. The problem of two equivalent nucleons outside a closed shell is treated in the same manner, and it is shown that the first and second excited states have spins 2 and 4 as usually observed. In addition there is a pairing energy binding effect in the ground state which is larger when the individual angular momenta of the two nucleons is larger. This is the pairing energy rule usually employed in shell model calculations. A.

539.152.1

1555. Mixed configurations in nuclei. A. DE-SHALIT AND M. GOLDHABER. *Phys. Rev.*, **92**, 1211–18 (*Dec.* 1, 1953).

The role of mixed configurations in nuclear states is discussed and illustrated by various examples; it is discussed in particular for β transitions with anomalous ft values and as a qualitative explanation of the empirically-found smooth variations of the first excited states of even-even nuclei. It is shown by various examples that a nucleon of one kind (neutron or proton) with a given j has a "stabilizing" influence on pairs of the other kind with a given j'. This stabilization effect is calculated on simplified assumptions for different j and j'. A.

539.152.1 : 537.533.74

High-energy electron scattering and nuclear structure determinations. *See Abstr.* 1389–90

539.152.1 : 539.185

1556. Nuclear scattering of high-energy neutrons. T. B. TAYLOR. Letter in *Phys. Rev.*, **92**, 831 (*Nov.* 1, 1953).

An attempt was made to fit the observed variation of the total cross-section with energy, in the range 50–400 MeV, by adjusting the parameters of the optical model of the nucleus. A graph is given of the energy dependence of these parameters, and a table of the nuclear radii determined from the best fit.

J. HUGHES

539.152.1 : 539.185

1557. Resonant effects and spin dependence in potential scattering of slow neutrons. W. SELOVE. *Phys. Rev.*, **92**, 941–2 (*Nov.* 15, 1953).

The potential scattering of a nucleus can be considerably different from $4\pi R^2$, where R is the size of the nucleus, if the potential well parameters happen to give an appreciable resonance effect. Strong resonance effects are expected to be accompanied by strong spin dependence. The potential scattering of beryllium shows an appreciable resonant effect but very small spin dependence in the scattering cross-section. From an examination of the numerical parameters involved it is concluded that the small spin dependence in the cross-section does not preclude a moderate amount of spin dependence in the potential wells for the two spin states—the close equality of the two scattering lengths involved may be the result of a coincidental combination of well depths and ranges. A.

539.152.2

1558. Magnetic moment of Li^6. T. KOMODA AND M. SASAKI. Letter in *Progr. theor. Phys.*, **8**, 669 (*Dec.*, 1952).

Theoretical. To explain the deviation of the magnetic moment of Li^6 from the value calculated on the basis of the j–j coupling model, a tensor interaction is introduced between the $2p$-proton and the $2p$-neutron. The experimental value is obtained with a D-state admixture of 7% to the S ground state. L. PINCHERLE

539.152.2

1559. The quadrupole moments of Sb^{121} and Sb^{123}. G. Sprague and D. H. Tomboulian. *Phys. Rev.*, **92**, 105–8 (*Oct.* 1, 1953).

An extension of the existing term analysis of the spectrum of Sb II has led to the reliable identification of lines which are known to exhibit well-resolved h.f.s. patterns. Among the few such lines which reveal a simple pattern are the three transitions whose wavelengths in angstroms are 5057, 5895 and 6806. Based on the measurements of the h.f.s. separations of these lines, it has been possible to arrive at values of the nuclear electric quadrupole moments of Sb^{123} and Sb^{121} from a study of the splitting of the $5s5p^3\ ^3P_1$, $5p6s\ ^3P_1$ and $5p6p\ ^3D_1$ states. Utilizing the recent value of the quadrupole-moment ratio as determined by microwave techniques, corrections have been applied for the perturbing effects of unassigned nearby levels. The present calculations yield the following results for the quadrupole moments of the two isotopes: $Q_{121} = -1{\cdot}3\times10^{-24}$ cm² and $Q_{123} = -1{\cdot}7\times10^{-24}$ cm². A.

539.152.2

1560. Sign of the quadrupole interaction of Li^6 in LiCl. P. Kusch. *Phys. Rev.*, **92**, 268–70 (*Oct.* 15, 1953).

The sign has been found to be positive. Previous determinations have shown that the quadrupole interaction energy of Li^7 in the same molecule is also positive. It may, therefore, be concluded that both of the stable isotopes of lithium have a quadrupole moment of the same sign, though the sign itself is not known. A.

539.152.2

1561. A note on the ratio of the quadrupole moments of Li^6 and Li^7. N. G. Cranna. Note in *Canad. J. Phys.*, **31**, 1185–6 (*Nov.*, 1953).

Accurate measurement of the ratio of the splittings in the nuclear magnetic resonance of Li in spodumene gives $|Q_6/Q_7| = (1{\cdot}9 \pm 0{\cdot}1)\times10^{-2}$. D. H. Whiffen

539.152.2

1562. The nuclear moments of technetium-99. K. G. Kessler and R. E. Trees. *Phys. Rev.*, **92**, 303–7 (*Oct.* 15, 1953).

The hyperfine structure in the optical spectrum of technetium has been investigated in the region 3600–7000 Å with a Fabry–Perot interferometer crossed with a quartz prism spectrograph. The light source was a liquid-nitrogen-cooled hollow cathode discharge tube. The nuclear-spin, magnetic moments previously reported (1951), by one of us are confirmed ($I = 9/2h$ and $\mu = 5{\cdot}5 \pm 0{\cdot}3$ nm), and are in agreement with a more recent nuclear induction measurement. The quadrupole moment of Tc^{99} is found to be: $Q = (+0{\cdot}34 \pm 0{\cdot}17)\times10^{-24}$ cm². A.

539.152.2

1563. Hyperfine structure formulas for *LS* coupling. R. E. Trees. *Phys. Rev.*, **92**, 308–14 (*Oct.* 15, 1953).

Formulae for the interval factor A and the quadrupole coupling factor B in the hyperfine structure formula $W = W_J + \frac{1}{2}AK + BK(K+1)$, are derived with Racah's tensor algebra. The results are directly applicable to light atoms ($Z < 50$) that show good *LS*-coupling. Data of White and Ritchl for manganese are analysed and an approximate value of the nuclear quadrupole moment in Mn^{55} of $Q = 1\times10^{-24}$ cm² is obtained. This confirms another approximate value of $Q = 0{\cdot}5\times10^{-24}$ cm² recently obtained by microwave methods. An error in the calculation carried out by Brown and Tomboulian to evaluate the Q of tantalum is noted. A relation satisfied by X-functions is derived, which simplifies their numerical evaluation. A.

539.152.2

1564. Hyperfine structure of the spectra of dysprosium, cobalt, vanadium, manganese, and lanthanum. K. Murakawa and T. Kamei. *Phys. Rev.*, **92**, 325–7 (*Oct.* 15, 1953).

Study of the hyperfine structure of the spectra of Dy I and Dy II yielded the result that the nuclear spins of Dy^{161} and Dy^{163} are very probably 7/2 and their nuclear magnetic moments are approximately equal. The quadrupole moments of Co, V, Mn and La were deduced by hyperfine structure investigation to be $Q(Co^{59}) = (0{\cdot}5 \pm 0{\cdot}2)\times10^{-24}$ cm², $Q(V^{51}) = (0{\cdot}3 \pm 0{\cdot}2)\times10^{-24}$ cm², $Q(Mn^{55}) = (0{\cdot}4 \pm 0{\cdot}2)\times10^{-24}$ cm² $Q(La^{139}) = (0{\cdot}9 \pm 0{\cdot}1)\times10^{-24}$ cm². The eccentricities of odd-proton nuclei were calculated from the existing data, and they were plotted *v.* the proton number. It was found that they attain large maxima in light and heavy elements. A.

539.152.2

1565. Polarization of nuclei in metals. A. W. Overhauser. *Phys. Rev.*, **92**, 411–15 (*Oct.* 15, 1953).

A new method for polarizing nuclei, applicable only to metals, is proposed. It is shown that if the electron spin resonance of the conduction electrons is saturated, the nuclei will be polarized to the same degree they would be if their gyromagnetic ratio were that of the electron spin. This action results from the paramagnetic relaxation processes that occur by means of the hyperfine structure interaction between electron and nuclear spins. A shift of the electron spin resonance due to the same interaction will occur for large amounts of polarization and should provide a direct indication of the degree of polarization. A.

539.152.2

1566. Polarization of nuclear spins in metals. T. R. Carver and C. P. Slichter. Letter in *Phys. Rev.*, **92**, 212 (*Oct.* 1, 1953).

Overhauser's prediction (preceding abstract) that the saturation of conduction electron spins should increase the population difference between nuclear Zeeman levels has been verified by observations on the 100-fold enhanced 50 kc/s nuclear resonance in Li^7. W. J. Swiatecki

539.152.2

1567. The coupling between the odd proton and the neutrons in Cu^{63} and Cu^{65}. M. Trocheris. Letter in *J. Phys. Radium*, **14**, 635–6 (*Nov.*, 1953) *In French.*

An attempt is made to calculate the magnetic and quadrupole moments, using the collective particle model to describe the interaction of the odd proton with the partially filled neutron shell. P. T. Matthews

539.152.2

1568. The magnetic moments of spin ½ nuclei. R. J. BLIN-STOYLE. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1158–61 (*Dec.*, 1953).

It is shown that the deviations of the magnetic moments of all spin ½ nuclei from the Schmidt limits can be adequately accounted for by simple inter-configurational mixing. A.

539.152.2

1569. The spin and magnetic moment of Ti^{47} and Ti^{49} and the magnetic moment of Ge^{73}. C. D. JEFFRIES. *Phys. Rev.*, **92**, 1262–3 (*Dec.* 1, 1953).

The spin and magnetic moment of Ti^{47} and Ti^{49} have been measured by nuclear induction. The results are: $I(Ti^{47}) = 5/2$, $I(Ti^{49}) = 7/2$, $\mu(Ti^{47}) = -(0{\cdot}78706 \pm 0{\cdot}0001)$ nm, $\mu(Ti^{49}) = -(1{\cdot}1022 \pm 0{\cdot}0002)$ nm. The magnetic moment of Ge^{73} has been measured by nuclear induction with the result: $\mu(Ge^{73}) = -(0{\cdot}87675 \pm 0{\cdot}00012)$ nm. These results are compared with the predictions of the shell model of nuclear structure. A.

539.152.2

1570. The nuclear spin and quadrupole moment of I^{131}. R. LIVINGSTON, B. M. BENJAMIN, J. T. COX AND W. GORDY. *Phys. Rev.*, **92**, 1271–2 (*Dec.* 1, 1953).

Measurements on the $J = 2 \rightarrow 3$ rotational transition of CH_3I^{131} have been made in the 6·75 mm wavelength region. The nuclear spin of I^{131} was found to be 7/2 and the quadrupole coupling, -973 ± 9 Mc/s. This coupling gives $-0{\cdot}412 \times 10^{-24}$ cm^2 for the quadrupole moment of I^{131}. A.

539.152.2

1571. A theoretical investigation of the nuclear resonance absorption spectrum of Al^{27} in spodumene. G. LAMARCHE AND G. M. VOLKOFF. *Canad. J. Phys.*, **31**, 1010–14 (*Sept.*, 1953).

A theoretical investigation is presented of the energy levels of a nucleus of spin $I = 5/2$, a given magnetic moment μ, and electric quadrupole moment eQ, placed in a uniform magnetic field H_0, and a crystalline electrostatic potential ϕ without axial symmetry. The dependence of the energy levels, line frequencies and transition matrix elements on the dimensionless parameter $R \equiv 4\mu H_0/eQ\phi_{zz}$ is calculated for Al^{27} for one orientation of a spodumene crystal in the magnetic field H_0 over the interesting range of the parameter R linking up the pure quadrupole with the Zeeman spectrum. Other orientations of the crystal are discussed briefly. A.

539.152.2

1572. A rapid method of obtaining nuclear magnetic resonance spectrograms. K. TAYLOR. Letter in *Nature* [*London*] **172**, 722–3 (*Oct.* 17, 1953).

A rapid field change up to 1000 gauss/sec, obtained by short-circuiting a resistance in series with the magnet, is used as the variable to display nuclear resonance with a fixed frequency of 3 Mc/s. Five lines due to the quadrupole splitting of Al^{27} are easily observed in one oscilloscope sweep.

D. H. WHIFFEN

539.152.2 : 536.48

Temperature dependence of the nuclear susceptibility of He^3 between 1·2°K and 4·2°K. *See Abstr.* 1245

539.152.2 : 539.132

1573. Correlation of proton magnetic resonance chemical shifts with electronegativities of substituents. J. N. SHOOLERY. Letter in *J. chem. Phys.*, **21**, 1899–900 (*Oct.*, 1953).

Fine structure of the proton resonance of the order of a few milligauss in some substituted ethanes is observed and attributed to different diamagnetic shielding at non-equivalent nuclei. Defining δ by $10^5(H_r - H_c)/H_r$ where H_r is the resonance field in ethane and H_c that for the H atom concerned in the compound, it is found that $E_s = 2{\cdot}1 + 4{\cdot}5(\delta_{CH_2} - \delta_{CH_3})$ where E_s is the Pauling electronegativity of the substituent. The shifts in aniline and benzaldehyde show that the electron density in the ring is increased and decreased respectively. D. H. WHIFFEN

539.152.2 : 539.155.2

1574. The spin of Si^{29} and mass ratios of the stable Si isotopes. R. L. WHITE AND C. H. TOWNES. *Phys. Rev.*, **92**, 1256–7 (*Dec.* 1, 1953).

The $J = 0 \rightarrow 1$ microwave transition of $Si^{29}D_3F$ has been examined under high resolution for hyperfine structure due to Si^{29}. No hyperfine structure was found, which sets an upper limit of 1×10^{-28} cm^2 to the quadrupole moment of Si^{29}. This is good evidence that the Si^{29} spin is 1/2. The measurement also allows an accurate determination of mass difference ratios for the Si isotopes. A.

539.152.2 : 539.172.4

1575. The relation between the theory of nuclear fission and the theory of nuclear quadrupole moments. D. PFIRSCH. *Z. Phys.*, **135**, *No.* 5, 593–601 (1953) *In German.*

In non-excited states, relevant for the quadrupole moments, the deformability of a nucleus is understandable on the basis of the uncertainty principle. In excited states, important in the case of fission, the deformability may be described in terms of a surface tension and electrostatic forces. These considerations remove the discrepancy between the theories of the two phenomena, as they refer to essentially different nuclear deformations. L. PINCHERLE

539.153

1576. Accidental degeneracy of hydrogen. T. A. S. JACKSON. Letter in *Proc. Phys. Soc.* [*London*] *A*, **66**, 958–9 (*Oct.*, 1953).

It is shown that the system has a vector integral which forms with the angular momentum vector a four-dimensional angular momentum tensor. This vector integral is essentially the quantal analogue of Hamilton's integral. By using it the possible negative energy levels can be obtained in an algebraic way.

P. M. DAVIDSON

539.153

1577. Introduction of exchange in the Thomas–Fermi model for atoms. N. H. MARCH. Letter in *Phil. Mag.*, **44**, 1193–6 (*Oct.*, 1953).

Scott's method [Abstr. 9001 (1952)] is extended by introducing a variational function for the electron density. An improved charge distribution is found and the virial theorem in the Thomas–Fermi theory is satisfied in this approximation. G. FIELD

539.153

1578. Electronic excitation of the L_{III} State of 5*d* elements. G. SCHWARZ AND G. L. ROGOSA. *Phys. Rev.*, **92**, 88–9 (*Oct.*1, 1953).

Experiments by Nilsson on the electronic excitation of the *K* state of 3*d* transition elements have revealed a structure in the excitation curves. Similar structure close to the excitation potential has been observed for the excitation of the L_{III} state of some 5*d* elements. A.

539.153

1579. Hyperfine structures of silver and gold by the atomic beam magnetic resonance method. G. WESSEL AND H. LEW. *Phys. Rev.*, **92**, 641–6 (*Nov.* 1, 1953).

An ionizer of the electron bombardment type has been applied to a beam of atoms in a magnetic resonance apparatus. The ionization efficiency for potassium atoms has been found to be 1 part in 3000. The new ionizer has made it possible to study the hyperfine structures and the *g* factors of the ground states of silver and gold, two elements which cannot be detected by the surface ionization method commonly used heretofore. The measurements yield the following results: $|\Delta\nu(Ag^{107})| = 1712{\cdot}56 \pm 0{\cdot}04$ Mc/s; $|\Delta\nu(Ag^{109})| = 1976{\cdot}94 \pm 0{\cdot}04$ Mc/s; $g_J(Ag)/g_J(Cs) = 0{\cdot}99987 \pm 0{\cdot}00010$; $|\Delta\nu(Au^{197})| = 6107{\cdot}1 \pm 1{\cdot}0$ Mc/s; $g_J(Au)/g_J(Cs) = 1{\cdot}00081 \pm 0{\cdot}00005$. A.

539.153 : 530.145

1580. Relativistic correction to the Lamb shift. M. BARANGER, H. A. BETHE AND R. P. FEYNMAN. *Phys. Rev.*, **92**, 482 (*Oct.* 15, 1953).

The relativistic corrections to the Lamb shift, i.e. terms of order $\alpha(Z\alpha)^5mc^2$, are calculated. For this purpose, the Lamb shift is separated into one term in which the Coulomb potential acts only once, and another term in which it acts two or more times. The one-potential term is shown to be equal to the expression calculated in previous papers except for corrections of order $\alpha(Z\alpha)^6$, and a method is given by which these corrections could be evaluated if desired. The many-potential term can be separated into a non-relativistic part which is again equal to the term calculated in previous papers, and a relativistic term which can be calculated by considering the intermediate states as free. The calculation of the latter term which, of course, involves the Coulomb potential exactly twice, is described. A correction to the vacuum polarization term which is of the same order, is evaluated. The result for the relativistic correction is 7·13 Mc/s, and is in agreement with the result of Karplus, Klein and Schwinger which was obtained by an independent method. The result for the complete Lamb shift has been given in a recent paper by Salpeter. The small remaining discrepancy of 0·6 Mc/s between theory and experiment might be due to the next order relativistic correction which should be of order $\alpha(Z\alpha)^6\ln(Z\alpha)$. A.

539.153 : 538.615

1581. The Zeeman effect of the Cr ground state. P. BRIX, J. T. EISINGER, H. LEW AND G. WESSEL. *Phys. Rev.*, **92**, 647–9 (*Nov.* 1, 1953).

The linear Zeeman effect of the ground state of Cr^{52} has been studied using the atomic beam magnetic resonance method at magnetic fields up to 850 gauss. The Cr atoms were detected by means of an electron-bombardment type ionizer. Using the known *g* factors for the ground states of K^{39} and Cs^{133}, the *g* factor of the $^7S_3$ ground state of neutral Cr was determined to be $g_J = 2(1{\cdot}00081 \pm 0{\cdot}00005)$. A.

539.153.4

1582. The hyperfine structure of hydrogen. R. ARNOWITT. *Phys. Rev.*, **92**, 1002–9 (*Nov.* 15, 1953).

The two-body formalism of Schwinger is modified to consider the case of the hydrogen atom. The proton's anomalous moment is treated by adding a Pauli-type term to the Lagrangian. A perturbation theory based upon the Green's function is developed and the first-order correction to the Fermi hyperfine splitting of the ground state is calculated. The method of calculation used is that of Karplus and Klein in their positronium work. Aside from the usual renormalizations encountered, an extra infinity appears in the calculation associated with the assumption of a point anomalous magnetic moment for the proton. On the hypothesis that the proton's moment is actually distributed, cutoffs are inserted. The modified hyperfine formula leads to a new value of α: $1/\alpha = 137{\cdot}0378$ for a cutoff at the meson length and $1/\alpha = 137{\cdot}0374$ for a cutoff at the proton length. A.

539.154 : 53.081

1583. Least-squares adjustment of the atomic constants, 1952. J. W. M. DUMOND AND E. R. COHEN. *Rev. mod. Phys.*, **25**, 691–708 (*July*, 1953).

A review of the group of constants and a determination by the method of least squares [see F. G. Dunnington, *Rev. mod. Phys.*, **11**, 65–83 (*April*, 1939)]. The group is determined by a precise knowledge of five of them, namely Sommerfeld's fine-structure constant, the velocity of light, the electronic charge, Avogadro's number and the conversion factor, which converts X-ray wavelengths from Siegbahn *X*-units to milliangstrom units. The reliability of the values is described by the standard deviation and correlation coefficients; these are calculated.

L. S. GODDARD

539.154 : 53.081 : 519.24

1584. The basis for the criterion of least squares. E. R. COHEN. *Rev. mod. Phys.*, **25**, 709–13 (*July*, 1953).

An addition to a previous paper (preceding abstract). The use of the method of least squares has been criticized on the ground that it assumes the Gaussian curve for the probability distribution of error. In spite of this the author justifies the use of the method. "Best" now means, not the solution which is most likely to be correct but the solution which is most accurate, and to which the greatest statistical weight may be attached. An example illustrates the method, and then the generalized theory of least squares is presented.

L. S. GODDARD

539.155

1585. Mass spectrum of gallium vapor. S. ANTKIW AND V. H. DIBELER. Letter in *J. chem. Phys.*, **21**, 1890–1 (*Oct.*, 1953).

The mass spectrum was investigated in the light of

calculations of the vapour pressure of Ga assuming it to be a monatomic vapour [Speiser and Johnston, *J. Amer. Chem. Soc.*, **75**, 1469 (1953)], the assumption being shown to be justified. The isotope ratio Ga^{69}/Ga^{71} was measured at temperatures between 865° and 1025°C, the observed value of the ratio being about 1·53. E. P. WOHLFARTH

539.155

1586. On the estimations of the mass differences of $C^{12}H_2$–N^{14}, $C^{12}H_4$–O^{16}, $C_2^{12}H_4$–N_2^{14} and $C_3^{12}H_4$–A^{40} with an electron impact ion source with a double focusing mass spectrograph. A. ENGLER AND H. HINTENBERGER. *Helv. phys. Acta*, **26**, *No.* 6, 657–62 (1953) *In German.*

The above mass differences were measured with a double focusing mass spectrograph of the Mattauch–Herzog type. The ions were obtained from an electron impact ion source combined with an electrostatic immersion lens. A short description of this arrangement is given. A.

539.155.2

1587. Enriching stable isotopes electromagnetically. C. P. KEIM. *J. appl. Phys.*, **24**, 1255–61 (*Oct.*, 1953).

The natural stable isotopes of 43 elements, comprising 177 different nuclides, have been enriched; the goal is to enrich 257 isotopes of 59 elements. The isotopic enrichments, the operation of the production mass spectrographs including a listing of best charge materials, a brief review of the chemical and analytical problems, a tabulation of the best compounds of the separated isotopes for mass spectrometer analysis and a listing of some of the major uses of separated isotopes have been included in this survey of the electromagnetic isotope separation programme. [See also Abstr. 470 (1952).] A.

539.155.2

1588. A comparison of lead isotope analysis techniques. R. M. FARQUHAR, G. H. PALMER AND K. L. AITKEN. Letter in *Nature* [*London*] **172**, 860 (*Nov.* 7, 1953).

The relative abundances of the lead isotopes were compared using solid lead compounds and lead tetramethyl as sources of ions in two mass spectrometers. The results from the two types of sample are in close agreement and the effects of mass discrimination appear negligible. D. R. CHICK

539.155.2 : 523.51 : 521.042

1589. Concentration of uranium and lead and the isotopic composition of lead in meteoritic material. C. PATTERSON, H. BROWN, G. TILTON AND M. INGHRAM. *Phys. Rev.*, **92**, 1234–5 (*Dec.* 1, 1953).

The cosmic abundance of lead and uranium have been determined by studying the lead and uranium contents of meteoritic materials. Lead is found to be present to 8×10^{-3} atom/10 000 atoms of silicon, and uranium to 1×10^{-4} atom/10 000 atom of silicon. The new value for lead removes the hump in the cosmic abundance curve in the 206–208 mass region. The relative primordial abundances of lead isotopes of mass 204, 206, 207 and 208 are found to be 1 : 9·4 : 10·3 : 29·2, respectively. A.

RADIOACTIVITY . α-, β- AND γ-RAYS 539.16

539.16

1590. Radioisotopes in industry. J. R. BRADFORD. *London: Chapman and Hall*, 309 *pp.*

Review in *Brit. J. appl. Phys.*, **4**, 317 (Oct., 1953).

539.16

1591. The use of radioactive isotopes in metallurgy. R. SHUTTLEWORTH. *Brit. J. appl. Phys.*, **4**, 326–9 (*Nov.*, 1953).

The γ-radiation from radioactive isotopes is used for radiography, β-radiation for gauging the thickness of foils or, by back scattering, the thickness of a coating on a base metal. The high sensitivity and ease with which isotopes can be detected and measured provides an easy method of estimating minute amounts of metal that have been labelled by pile irradiation. The most important metallurgical use of isotopes is in the measurement of self-diffusion coefficients, and a technique is described by which the two self-diffusion coefficients of copper and zinc in brass have been determined simultaneously. A number of methods of estimating activity are briefly described (Geiger-, proportional- and scintillation-counters and microautoradiography). A.

539.16 : 531.752

Precision balances for radioisotopic applications. *See Abstr.* 1084

539.16.08

1592. Operation of a Glaser bubble chamber with liquid hydrogen. R. H. HILDEBRAND AND D. E. NAGLE. Letter in *Phys. Rev.*, **92**, 517 (*Oct.* 15, 1953).

Liquid H_2 in an inverted bulb at its saturation temp. corresponding to a vapour pressure of $3\frac{1}{3}$ atm. could be kept superheated for up to 70 sec after the pressure was suddenly reduced to 1 atm. The boiling triggered immediately when the bulb was exposed to a 15 millicurie Co^{60}-source 5 metres away. Similar results with liquid N_2 at higher pressures. H. LONDON

539.16.08

1593. Radioactive contamination detector. M. BRIÈRE AND J. WEILL. *J. Phys. Radium*, **14**, 623–4 (*Nov.*, 1953) *In French.*

The instrument, described as robust and rapid in use, comprises a simple ratemeter circuit which can be switched to suitably mounted Geiger counters to test for contamination on the hands, feet or clothes.

L. E. MUSSELL

539.16.08 : 535.376

1594. Radiophotoluminescence dosimetry system of the U.S. Navy. J. H. SCHULMAN, W. SHURCLIFF, R. J. GINTHER AND F. H. ATTIX. *Nucleonics*, **11**, 52–6 (*Oct.*, 1953).

The dosimeter consists of a block of Ag-activated phosphate glass. After irradiation by X-rays or γ-rays the glass exhibits a permanent orange fluorescence when illuminated by near-ultraviolet radiation of 3650 Å. The fluorescence is due to the excitation of "atomic" silver centres, which are formed during the irradiation when electrons are trapped by Ag^+ ions of the glass. The intensity of fluorescence is proportional to the total dosage received. The glass

is kept in a water-tight plastic locket and is sandwiched between two lead washers to reduce the energy dependence of the dosimeter below 200 keV. A fluorimeter, used to observe and measure the intensity of fluorescence, is described. L. R. SHEPHERD

539.16.08 : 539.162

1595. Occurrence of nonequilibrium atmospheric mixtures of radon and its daughters. E. C. TSIVOGLOU, H. E. AYER AND D. A. HOLADAY. *Nucleonics*, **11**, 40–5 (*Sept.*, 1953).

The method of analysing the decay curves of the α-activities collected on filter papers, to obtain the relative concentrations of RaA, RaB and RaC in the sampled air, is described. The accuracy of the method is discussed. Experimental procedures are outlined and results of measurements made on air samples collected in uranium mines, are given. The results of ionization chamber measurements to determine the radon concentrations are also given. It was found that the concentrations of the daughter products generally fell below the equilibrium values, particularly when the ventilation in the mine was high.

L. R. SHEPHERD

539.16.08 : 539.169

1596. Monitoring of water for fission-product contamination. W. R. LOOSEMORE. *Nucleonics*, **11**, 36–40 (*Oct.*, 1953).

A low-voltage G.M. counter with a thin glass wall, and a surrounding annular space for the monitored liquid, is described. Experimental data on the energy-dependence of the β and γ counting efficiencies are given and the influence of the time variation of the energies of the fission-product radiations, on the interpretation of the observed counting rates, is discussed. The range of operation is 5×10^{-4} to $0{\cdot}5$ μC/ml and the accuracy attainable is $\pm25\%$. L. R. SHEPHERD

539.162

1597. A theorem concerning angular correlations. J. WENESER AND D. R. HAMILTON. *Phys. Rev.*, **92**, 321–2 (*Oct.* 15, 1953).

It is shown that in a cascade of any number of basic transitions between states of monotonically increasing or decreasing angular momenta the angular correlation between any two of the radiations is independent of the spins, the number and character of the intermediate steps and the order in which the radiations occur. It depends only on the character of the measured radiations. A.

539.163

1598. Theory of angular correlations of nuclear radiations. L. C. BIEDENHARN AND M. E. ROSE. *Rev. mod. Phys.*, **25**, 729–77 (*July*, 1953).

This review formulates the theory in a general fashion and considers in detail various special cases. These include γ-radiations, conversion electrons and β-radiation, magnetic effects and triple correlation. Specific experimental results are not discussed.

P. T. MATTHEWS

539.163

1599. Angular distribution of radiation emitted by arbitrary ensembles of nuclei. J. A. M. COX AND S. R. DE GROOT. *Physica*, **19**, 683–8 (*Aug.*, 1953).

An arbitrary ensemble is described by a density matrix ρ with arbitrary values of its matrix elements. An equivalent description is given by Fano's statistical tensors, which are used in this paper. A simple closed formula for the angular distribution of nuclear radiation from an arbitrary ensemble is derived. A.

539.163

1600. An analysis of the angular correlation experiment with a report of such measurements on Ni^{60}. S. CHATTERJEE AND A. K. SAHA. *Z. Phys.*, **135**, *No.* 2, 141–51 (1953) *In German.*.

An analysis of the assumptions is carried out and a general expression deduced for the observation time necessary to keep errors within a chosen amount. A theoretical formula for the effect of Compton scattering is given. This agrees with experimental results. The effect of angular scattering, limited by the finite dimensions of the counter, on the correlation is also calculated. Results agree with published values. Improvements are suggested. F. R. HOLT

539.163

1601. The total disintegration energy of P^{29}. H. RODERICK AND C. WONG. Letter in *Phys. Rev.*, **92**, 204 (*Oct.* 1, 1953).

The total disintegration energy (β^+ end-point energy $+2mc^2$) was found to be $4{\cdot}967 \pm 0{\cdot}010$ MeV.

J. M. CASSELS

539.163

1602. Isomeric states of molybdenum-93. L. KATZ AND J. GOLDEMBERG. Letter in *Nature* [*London*] **172**, 723–4 (*Oct.* 17, 1953).

Discusses the yields of Mo^{93m} in various nuclear reactions, in terms of the spin changes involved.

A. O. STANESBY

539.163

1603. Isomerism in Pb^{206}. D. E. ALBURGER AND M. H. L. PRYCE. Letter in *Phys. Rev.*, **92**, 514 (*Oct.* 15, 1953).

The energy levels of Pb^{206} have been investigated by observing conversion-line energies and intensities, coincidences between K conversion lines and coincidences between K conversion lines and γ-rays produced by the decay of Bi^{206} to Pb^{206}. A tentative level scheme involves 26 transitions. The half-life of the Pb^{206} isomeric state was measured as 145 ± 15 μsec.

D. R. CHICK

539.163

1604. Radioactivity of neutron excess iridium isotopes. F. D. S. BUTEMENT AND A. J. POË. *Phil. Mag.*, **45**, 31–7 (*Jan.*, 1954).

The half-lives, mass assignments and radiation characteristics have been determined. The γ-ray energies of 19 hr Ir^{194} have also been examined. The 7 sec Ir^{194m} isomer is either a 125 keV E3 transition followed by the $5{\cdot}6$ MeV γ-ray or possibly a $5{\cdot}6$ MeV M6, E6 or E7 transition followed by a 125 keV M1, E2 or E3 γ-ray. The latter alternative would be the highest spin-change γ-decaying isomer yet discovered and both are unusual in the very high energy transition involved. A.

539.163 : 539.172.4

1605. Spontaneous fission yields from uranium and thorium. G. W. WETHERILL. *Phys. Rev.*, **92**, 907–12 (*Nov.* 15, 1953).

Relative spontaneous fission yields from uranium and thorium have been determined by extracting

xenon and krypton from geologically old uranium and thorium minerals and measuring the isotopic abundances of these gases in a mass spectrometer. Arguments are presented for believing that the anomalous isotopic abundances observed are caused by spontaneous fission rather than by some other fission process. The spontaneous fission yield curve peaks were found to be much sharper than those associated with other fission processes. Evidence was found for fine structure in the fission yield curve at mass 132, possibly connected with preferential formation of spontaneous fission fragments containing 50 protons and 82 neutrons. Evidence for neutron induced fission in pitchblende was found. A.

539.163.1

1606. Upper limit to the mean life of the 1·33 MeV excited state of Ni^{60}. S. Gorodetzky, A. Knipper, R. Armbruster and A. Gallmann. Letter in *J. Phys. Radium*, **14**, 550–1 (*Oct.*, 1953) *In French.*

Delayed γ-γ coincidence measurements have indicated the upper limit $0{\cdot}7\times10^{-9}$ sec. J. J. Wilkins

539.163.1

1607. The half-lives of Fe^{59} and of Zn^{65}. J. Tobailem. Letter in *J. Phys. Radium*, **14**, 553 (*Oct.*, 1953) *In French.*

The system of 2 balanced ionization chambers [Abstr. 2934 (1952)] has been improved in sensitivity and stability; the $\frac{1}{2}$-lives of Fe^{59} and Zn^{65}, purified by paper chromatography, were measured as Fe^{59} : 45·0 ± 0·2, Zn^{65} : 245·0 ± 0·8 days.

A. O. Stanesby

539.163.1

1608. Half-life of Zr^{88}. E. K. Hyde. *Phys. Rev.*, **92**, 927 (*Nov.* 15, 1953).

The half-life of Zr^{88} has been determined to be 85 days by following the growth and decay of its 105-day Y^{88} daughter. A.

539.163.1

1609. Technetium of mass number 98. J. K. Lerohl, M. L. Pool, D. N. Kundu and R. A. House. *Phys. Rev.*, **92**, 934 (*Nov.* 15, 1953).

By (p, n) reactions on enriched molybdenum isotopes, it has been found that Tc^{98} does not have a half-life in the neighbourhood of either 42 min or 2·8 days as had been variously claimed. A.

539.163.1

1610. Formation of the long-lived Bi^{210} isomer. D. J. Hughes and H. Palevsky. *Phys. Rev.*, **92**, 1206–10 (*Dec.* 1, 1953).

The thermal activation cross-section of Bi^{209} is shown to be definitely less than the absorption cross-section, 19 ± 2 mb as compared with 33 ± 2 mb. In order to verify the high absorption value, previously obtained by pile reactivity methods, measurements were made with the long wavelength neutrons available with the Brookhaven slow chopper. The absorption cross-section is obtained from the chopper measurements by subtraction of thermal inelastic scattering. The latter scattering is determined from the variation of measured scattering with sample temperature. The difference between the absorption and scattering, or 14 ± 3 mb, is ascribed to the formation of the long-lived α-emitting isomeric state of Bi^{210}, leading to a half-life of $(2{\cdot}6 \pm 0{\cdot}8)\times10^6$ yr. This long-life is in agreement with the expected properties, relative to α and β decay, of a high-spin state of Bi^{210}. A.

539.163.1

1611. Lifetime measurements for the first excited states of O^{17} and B^{10} from recoil studies. J. Thirion and V. L. Telegdi. *Phys. Rev.*, **92**, 1253–5 (*Dec.* 1, 1953).

The following lifetimes have been measured: O^{17} 870 keV level $(2{\cdot}5 \pm 1)\times10^{-10}$ sec; B^{10} 720 keV level, $(7 \pm 2)\times10^{-10}$ sec. These values are compared with theoretical estimates based on the independent-particle model. Core excitation is required to explain the O^{17} lifetime. A.

539.163.2

1612. The decay of Zn^{65} and forbidden transitions of order $\Delta L = 2$. R. Bouchez, P. Hubert, N. Perrin and M. Sakai. *J. Phys. Radium*, **14**, 29 S–30 S (*Oct.*, 1953) *In French.*

The *ft* value and nuclear theory suggest that the β^+ decay is second forbidden, with $\Delta L = 2$ and $\Delta J = 1$. Small deviations from the allowed spectrum would be expected, but these were not found experimentally. The deviations would be obscured if some transitions of the type $\Delta L = 0$, $\Delta J = 1$ occur. A sensitive test is the ratio of K captures to β^+ decays, and measurements suggest that $\Delta L = 0$ transitions do indeed take place. J. M. Cassels

539.163.2

1613. The radioactive decay of tungsten 181. J. M. Cork, W. H. Nester, J. M. LeBlanc and M. K. Brice. *Phys. Rev.*, **92**, 119–20 (*Oct.* 1, 1953).

Using tungsten enriched in mass 180, neutron capture produces a strong activity in W^{181} with a half-life of about 140 days. Using scintillation crystal and photographic magnetic spectrometers, two γ-rays of energy 136·5 and 152·5 keV are found to occur. Neither of these had been previously observed and conversely none of the previously reported γ energies are found to exist. The main decay of W^{181} takes place by K capture directly to the ground state of Ta^{181}. Coincidence measurements are made with some evidence that the γ-rays are in sequence. A.

539.163.2

1614. The decay of Ta^{183}. J. W. M. DuMond, H. C. Hoyt, P. E. Marmier and J. J. Murray. Letter in *Phys. Rev.*, **92**, 202 (*Oct.* 1, 1953).

Pile irradiation of Ta produced 5·2 ± 0·1 day Ta^{183} by two successive neutron captures in Ta^{181}. The capture cross-section of Ta^{182} is about 10^4 barns, the β^- end-point is 558 ± 10 keV, and the energies and relative intensities of 21 γ-ray lines are given.

J. M. Cassels

539.163.2

1615. The 1·25-minute Rb^{82m} daughter of 27-day Sr^{82}. L. M. Litz, S. A. Ring and W. R. Balkwell. *Phys. Rev.*, **92**, 288–90 (*Oct.* 15, 1953).

The 3·15 MeV positron associated with the decay of the 27-day Sr^{82} has been found to arise from the decay of a 1·25-minute metastable Rb^{82} isomer by an allowed transition to the Kr^{82} ground state. No isomeric transition to the 6·3-hour Rb^{82} ground state was observed. A tentative decay scheme and spin and parity assignments are discussed. A.

539.163.2

1616. The radiations of $_{64}Gd^{159}$ (18 hr) and $_{64}Gd^{161}$ (3·7 min). W. C. JORDAN, J. M. CORK AND S. B. BURSON. *Phys. Rev.*, **92**, 315–18 (*Oct.* 15, 1953).

The radiations from $_{64}Gd^{159}$ (18 hr) and $_{64}Gd^{161}$ (3·7 min) are studied with 180° photographic electron spectrometers and a scintillation coincidence spectrometer. $_{64}Gd^{159}$ (18 hr): Interval conversion lines corresponding to γ transitions of $57{\cdot}5 \pm 0{\cdot}3$ and 364 ± 3 keV are observed. Peaks due to the K X-ray and the 364 keV γ-ray are observed in the NaI pulse-height distribution. The results of coincidence measurements indicate that the two γ transitions are not in cascade, but that the 57 keV one is preceded by a β transition of $\sim 1{\cdot}1$ MeV, while the 364 keV one is preceded by a β transition of $\sim 0{\cdot}9$ MeV. $_{64}Gd^{161}$ (3·7 min): The half-life of this activity is found to be $3{\cdot}73 \pm 0{\cdot}10$ min. Aluminium absorption measurements indicate an energy of $\sim 1{\cdot}6$ MeV for the β transition. Peaks are observed in the pulse-height distribution corresponding to 44 ± 1 (Tb K X-ray), 102 ± 3, ~ 165 and ~ 360 keV. The high-energy peak is resolved into two peaks in coincidence distributions, showing the 360 keV transition to be coincident with the X-ray, and a 316 keV transition to be coincident with the 102 keV γ-ray. The K internal conversion line for the 316 keV transition is observed, plus some other weak conversion lines corresponding to the other transitions. All of the electromagnetic radiation appears to be coincident with a β transition of $\sim 1{\cdot}6$ MeV. The existence of a γ transition of ~ 60 keV is suggested. A.

539.163.2

1617. Disintegration scheme of Br^{80} (18 min). G. SCHARFF-GOLDHABER AND M. MCKEOWN. *Phys. Rev.*, **92**, 356–8 (*Oct.* 15, 1953).

The 18 min isomer Br^{80} is shown to emit γ-rays of 620 keV energy which follow a low intensity ($9 \pm 2\%$) β-ray branch. β-γ coincidences are observed, indicating that the γ transition takes place in Kr^{80}. No γ-ray transition was found to follow the positron or K capture branch. The intensity observed is compatible with a spin and parity assignment 1+ for the ground state of Br^{80}, while the 620 keV state in Kr^{80} is probably 2+. The γ-ray energy observed fits well into the pattern for the energy of the first excited state of even-even nuclei. A.

539.163.2

1618. The radioactive decay of calcium 47. J. M. CORK, J. M. LEBLANC, M. K. BRICE AND W. H. NESTER. *Phys. Rev.*, **92**, 367–9 (*Oct.* 15, 1953).

Spectrometric studies have been made of the β and γ radiations from calcium 47 (5·35 day) and its radioactive daughter scandium 47 (3·4 day). Using conversion and photoelectrons and the scintillation spectrometer, γ-rays of energy 149·5, 234, 495, 800 and 1303 keV are found in scandium following β emission from the calcium. The β spectrum is complex with energies of 0·46 and 1·4 MeV. Scandium 47 decays with a single allowed β transition with upper energy limit of $0{\cdot}64 \pm 0{\cdot}03$ MeV and a single γ-ray of 159·5 keV. A satisfactory level scheme is proposed for the decay and checked in some of its details by coincidence observations. A.

539.163.2

1619. A long-lived activity in neutron-irradiated niobium. D. L. DOUGLAS, A. C. MEWHERTER AND R. P. SCHUMAN. *Phys. Rev.*, **92**, 369–71 (*Oct.* 15, 1953).

An activity has been found in samples of niobium metal irradiated for long periods in the Chalk River reactor. Extensive chemical tests showed that the activity is niobium. The activity is most likely the long-lived ground state of Nb^{94}. If so, its half-life is estimated as $(2{\cdot}2 \pm 0{\cdot}5) \times 10^4$ years from its yield. It has a $0{\cdot}50 \pm 0{\cdot}05$ MeV β and three γ's, $0{\cdot}70 \pm 0{\cdot}01$ MeV (92%), $0{\cdot}87 \pm 0{\cdot}01$ MeV (92%) and $1{\cdot}57 \pm 0{\cdot}02$ MeV (8%). The capture cross-section of Nb^{94} is 15 ± 4 barns. A.

539.163.2

1620. Metastable states of Ge^{73}. J. P. WELKER, A. W. SCHARDT, G. FRIEDLANDER AND J. J. HOWLAND, JR. *Phys. Rev.*, **92**, 401–5 (*Oct.* 15, 1953).

The decay of As^{73} to Ge^{73} has been investigated with scintillation counters. The K-capture is followed by a 53·9 keV γ-ray which in turn is followed by a 13·5 keV transition to the ground state. The total conversion coefficient of the 53·9 keV γ is 4·7 and the lifetime is between 900 μsec and 10 sec. The half-life of the 13·5 keV transition is 4·6 μsec. The available evidence points to the 53·9 keV transition being $M2$ and the 13·5 keV transition $E2$ with a possible small admixture of $M1$. Spin and parity assignments are discussed. A.

539.163.2

1621. Isomeric state of Ag^{109}. P. AVIGNON. Letter in *J. Phys. Radium*, **14**, 636–7 (*Nov.*, 1953) *In French.*

Proportional counter measurements indicated a γ-ray of 87 ± 1 keV, with $\alpha_k = 8{\cdot}6 \pm 1{\cdot}0$ (as expected for an $E3$ transition). J. J. WILKINS

539.163.2

1622. Transition $Pd^{103} \rightarrow Rh^{103}$. P. AVIGNON. Letter in *J. Phys. Radium*, **14**, 637–8 (*Nov.*, 1953) *In French.*

Proportional counter measurements gave the results $\alpha_k = 70$ and $\alpha_k/\alpha_L = (15{\cdot}7 \pm 3) \times 10^{-2}$ for the 40 keV (isomeric) γ-ray. The fraction of transitions occurring by K-capture $= 0{\cdot}56 \pm 0{\cdot}07$, indicating a transition energy $= 36 \pm 5$ keV. J. J. WILKINS

539.163.2

1623. The decay of Cd^{105}. F. A. JOHNSON. *Canad. J. Phys.*, **31**, 1136–47 (*Nov.*, 1953).

The isotope Cd^{105} (55 min) has been produced by the Ag^{107} (p, $3n$) reaction in the McGill University synchrocyclotron and has been investigated by means of a 180° spectrograph of high resolution, a lens spectrometer and a scintillation spectrometer. The positron end point was found to be $1{\cdot}691 \pm 0{\cdot}005$ MeV and the Fermi plot of the spectrum was straight down to about 800 keV where a slight upward curvature began. Internal conversion lines found in the 180° spectrograph indicated γ-rays of energies 25·50, 27·69, 263·0, 292·5, 308·0, 312·1, 317·1, 320·5, 324·9, 336·3, 340·7, 347·0, 433·1 and 606·7 keV. High-energy internal conversion lines found in the lens spectrometer beyond the end point of the positron spectrum were assigned to γ-rays of energies 1·908, 1·957, 1·995, 2·045, 2·277 and 2·318

MeV. In addition lines assigned to Ag^{105} have been recorded. These correspond to γ-rays of energies 64·0, 280·8, 319·4, 331·5, 344·9, 392·6 and 443·2 keV, of which that of 331·5 keV has not been reported previously. A.

539.163.2

1624. Decay of gallium 67. W. E. Meyerhof, L. G. Mann and H. I. West, Jr. *Phys. Rev.*, **92**, 758–65 (*Nov.* 1, 1953).

The decay of Ga^{67} has been investigated with scintillation spectrometers, single and in coincidence. No positrons have been found, in agreement with the total decay energy of 1·003 MeV measured by Trail and Johnson. Electron capture occurs to levels in Zn^{67} at 0·092, 0·182, 0·39 and 0·87 MeV. The 0·092 MeV level of Zn^{67} has a half-life of $9·5 \pm 1·0$ μsec and the total conversion coefficient of the 0·092 MeV γ-ray is $0·54 \pm 0·05$. Rough measurement of the angular correlation coefficient between the 0·21 MeV and 0·18 MeV γ-rays (cascading from the 0·039 MeV level of Zn^{67}) gives $-0·22 \pm 0·04$. Spin and parity assignments of the Zn^{67} levels are discussed. The present work is in essential agreement with that of Ketelle, Brosi and Porter. A.

539.163.2

1625. The radioactive decay of ^{41}Ca. F. Brown, G. C. Hanna and L. Yaffe. *Proc. Roy. Soc. A*, **220**, 203–19 (*Nov.* 10, 1953).

See Abstr. 2943 (1952). A full description is now given including further results. The nuclide decays by orbital electron capture with a half-life of $1·1 \pm 0·3 \times 10^5$ yr. The assignment of this activity to Ca^{41} is discussed and the half-life is compared with the values obtained from β-decay theory. A.

539.163.2

1626. Decay of Rh^{106}. B. Kahn and W. S. Lyon. *Phys. Rev.*, **92**, 902–3 (*Nov.* 15, 1953).

The γ radiations from 30 sec Rh^{106} have been examined using a NaI(Tl) γ-ray spectrometer. These consist of: 0·516 MeV (20·5%), 0·619 MeV (10·4%), 0·88 MeV (0·3%), 1·04 MeV (1·7%), 1·14 MeV (0·4%), 1·54 MeV (0·2%) and several γ-rays of higher energies with intensities of less than 0·1%. A.

539.163.2

1627. Neutron-deficient isotopes of thallium. I. Bergström, R. D. Hill and G. de Pasquali. *Phys. Rev.*, **92**, 918–23 (*Nov.* 15, 1953).

The activities of the *K*-capturing isotopes of $Tl^{198-202}$ have been investigated. Using 180° β-ray spectrographs, more than 150 conversion lines have been observed. A new isomer of 1·9 hr half-life has been found and assigned to mass number 198. There are three γ-rays of 282·4, 260·7 (isomeric) and 48·7 keV associated with this activity. No thallium isomers, other than Tl^{198m}, or mercury isomers, other than the already known Hg^{199m}, were found. The first excited states in Hg^{200} and Hg^{202} were found to be 2+ states. The level schemes of Hg^{198} and Hg^{200} are complex. A.

539.163.2

1628. The decay scheme of krypton-83. P. Swinbank and J. Walker. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1093–6 (*Dec.*, 1953).

The occurrence of a nuclear level preceding the 1·9 hr metastable state in Kr^{83} has been confirmed. The associated transition has been shown to be of magnetic dipole type, of energy 51 keV and half-life less than 5×10^{-8} sec. A.

539.163.2

1629. Decay of $_{66}Dy^{165m}$ (1·2 min) and $_{66}Dy^{165}$ (2·3 hr). W. C. Jordan, J. M. Cork and S. B. Burson. *Phys. Rev.*, **92**, 1218–21 (*Dec.* 1, 1953).

The activities induced by neutron capture in Dy^{164} have been studied with 180° photographic internal conversion electron spectrometers and a scintillation coincidence spectrometer. The metastable transition energy is $108·0 \pm 0·2$ keV. Other γ-rays of approximately 160, 360 and 515 keV are associated with the 1·2 min activity and appear to follow β decay from the metastable level. γ-rays of $94·4 \pm 0·2$, $279·4 \pm 0·8$, $361·2 \pm 1·0$, 634 ± 3, 710 ± 20 and 1020 ± 30 keV follow the 2·3 hr β decay from the ground state. Coincidences are observed between members of the pairs (279)–(710) and (361)–(634). The 94 keV γ-ray is coincident with a β transition of about 1·2 MeV, while the other γ radiations are coincident with a softer β component (~0·3 MeV). A.

539.163.2

1630. The decay scheme of Ag^{108}. M. L. Perlman, W. Bernstein and R. B. Schwartz. *Phys. Rev.*, **92**, 1236–40 (*Dec.* 1, 1953).

The radiations of 2·3 min Ag^{108} have been examined with scintillation and proportional counter spectrometers and with a coincidence spectrometer. The transitions and their abundances were found to be as follows: β^- 1·77 MeV (97·3%); β^- 1·15 MeV accompanied by γ of energy 0·62 MeV (0·8%); β^+ (0·14%); and *K* capture to ground and excited states of Pd^{108} (1·6%). γ-rays of energies 0·60 MeV and 0·43 MeV were found to accompany *K* capture; the abundances of the different capture transitions were measured. Spin and parity assignments were made. A.

539.163.2

1631. Erbium^{163} and thulium^{165}. T. H. Handley and E. L. Olson. *Phys. Rev.*, **92**, 1260–1 (*Dec.* 1, 1953).

A 75-minute activity produced by bombarding Ho^{165} with protons is assigned to Er^{163}. A 24·5-hr activity produced by proton bombardment of erbium is assigned to Tm^{165}. γ-ray spectra are given for both isotopes. A.

539.164

1632. Measurement of the mean energy of alpha particles emitted by samarium using nuclear emulsions. D. Szteinsznaider. *J. Phys. Radium*, **14**, 465–72 (*July–Aug.–Sept.*, 1953) *In French.*

A detailed account is given of the measurements of the ranges of α-particles due to Sm and to the reactions $B^{10}(n, \alpha)Li^7$ and $Li^6(n, \alpha)H^3$ in nuclear emulsions. A value of $2·12 \pm 0·03$ MeV is obtained for the mean energy of the α-particles emitted by Sm based on the measured ranges and known energies of the α-particles due to the disintegration of B^{10} and Li^6. This value can be compared with previously published values of $2·18 \pm 0·02$ MeV and $2·06 \pm 0·02$ MeV based on range measurements in argon and air respectively.

A. C. COATES

539.164

1633. Alpha spectrometry with the pulse ionization chamber. G. VALLADAS AND L. COHEN. *J. Phys. Radium*, **14**, 26 S–27 S (*Oct.*, 1953) *In French.*

By reduction of amplifier noise, a standard error of 16 keV on the measurement of the energy of an α-particle has been achieved. A measurement of the ionium α-particle spectrum is reported. J. J. WILKINS

539.164 : 539.166

1634. Alpha-gamma angular correlation in ionium (Th^{230}). G. M. TEMMER AND J. M. WYCKOFF. *Phys. Rev.*, **92**, 913–17 (*Nov.* 15, 1953).

The angular correlation between the α-particle leading to the first excited state of Ra^{226} at 67·8 keV and the subsequent γ-ray to the ground state leads to a definite assignment of $I = 2^+$ for this state. The correlation is weakened by what is believed to be an interaction of the nuclear electric quadrupole moment with crystalline electric field gradients in the source. The lifetime of the excited state is about 1×10^{-8} sec. A.

539.165

1635. The decay energies of Pb^{209} and Si^{31}. A. H. WAPSTRA. *Ark. Fys.*, **6**, *Paper* 26, 263–7 (1953).

An intermediate-image β-spectrometer was calibrated with electron lines of known energy. The β-decay energies of Pb^{209} and Si^{31} were determined and found to be 635 ± 10 keV and 1486 ± 12 keV respectively. A.

539.165

1636. Preparation and study of UZ(Pa^{234}) and study of its β-radiation. G. BOUISSIÈRES, N. MARTY AND J. TEILLAC. *C.R. Acad. Sci.* [*Paris*] **237**, 324–26 (*July* 27, 1953) *In French.*

Magnetic lens spectrometer measurements revealed 12 conversion lines of 83 to 836 keV energy. Probable γ-ray energies are suggested. The continuous β-spectrum contains a 75% component with end-point $\simeq$0·5 MeV, plus one (0·98 MeV) or two (0·9 and 1·35 MeV) higher energy components. J. J. WILKINS

539.165

1637. Beta-spectrum of Ni^{63}. Y. KOBAYASHI, G. MIYAMOTO AND S. MORI. Note in *J. Phys Soc. Japan*, **8**, 684–5 (*Oct.*, 1953).

The β-spectrum from ½ keV to the end point at 61·5 ± 1 keV was examined in an electrostatic spectrometer. A linear Fermi plot is obtained using a first-forbidden correction factor. M. A. GRACE

539.165

1638. An influence function for the beta activity of uranium-235 fission products. J. K. THORNTON AND W. J. HOUGHTON. *J. appl. Phys.*, **24**, 1374–8 (*Nov.*, 1953).

Computations have been made of the total β-activity of the fission products arising from the slow neutron fission of U^{235}. A curve is given exhibiting the activity per unit fission, for time intervals after fission ranging from 0·01 sec to 10 yr. This influence function is compared with some published experimental data and with the statistical curve of Way and Wigner. A curve of its integral as a function of the upper limit is also given. This latter curve facilitates estimation of the activity in the particular case where the fission rate has been constant throughout a known time interval. Finally, an influence function for the particular group of fission products consisting of complete and partial chains having volatile first members is given. A.

539.165

1639. Scintillation spectrometer determination of *L*-capture to *K*-capture ratio in Cd^{109} and I^{125}. E. DER MATEOSIAN. *Phys. Rev.*, **92**, 938–40 (*Nov.* 15, 1953).

A useful technique of scintillation spectrometry developed in this laboratory—that of growing crystals containing radioactive nuclei—was employed to measure the *L*-capture to *K*-capture ratio in the orbital electron capture occurring in Cd^{109} and I^{125}. Marshak's formulae were used to calculate the energy of the transition. The *L*-capture to *K*-capture ratio and the energy of the transition are reported as 0·28 ± 0·03 and 73^{+12}_{-6} keV for Cd^{109}, and 0·23 ± 0·03 and 108^{+20}_{-10} keV for I^{125} respectively. A.

539.165 : 539.166

1640. Beta-gamma polarization correlations. D. R. HAMILTON, A. LEMONICK AND F. M. PIPKIN. *Phys. Rev.*, **92**, 1191–8 (*Dec.* 1, 1953).

The polarization of the γ-ray emitted at an angle of 90 degrees to the preceding β-particle has been measured for certain β-γ cascades in potassium-42, arsenic-76, rubidium-86, antimony-124 and caesium-134, as selected by β absorbers when necessary. The polarimeter was checked by observing the polarization of the γ-rays of caesium-137 and cobalt-60 when Compton-scattered through 90 degrees. Of the γ's investigated, those of potassium-42 and caesium-134 have no observable polarization. For the other three elements, the sign of the polarization correlation, taken in combination with the sign of the angular correlation reported by other observers, uniquely determines that no parity change occurs in the γ-emission, corresponding to electric quadrupole radiation in decay of the excited state. A.

539.165 : 771.534

The action of β-rays from Tl^{204} and from Sr^{90} on ordinary photographic films. *See Abstr.* 1934

539.165 : 778.34

Autoradiography of the β rays of potassium. *See* **Abstr.** 1941

539.165.08

1641. The isomeric transition of Pb^{207} as an energy standard in beta spectroscopy. D. E. ALBURGER. *Phys. Rev.*, **92**, 1257–9 (*Dec.* 1, 1953).

The *K*-conversion line of the 1·06 MeV isomeric transition following the electron capture decay of Bi^{207} is suggested as a useful energy standard for β-spectroscopy. While the 50-year half-life and 10% conversion coefficient are comparable to Cs^{137}, the 60% higher energy, larger percentage *K* to *L* momentum separation and the possibility of making thin and more uniform sources may be advantageous. Precision measurements have been carried out in a double-focusing spectrometer by comparison with the 1·02 MeV electrons of RaC. The Pb^{207} *K*-line has a momentum of 4657·9 ± 1·0 gauss-cm from which an electron energy of 975·9 ± 0·3 keV and a transition

energy of 1063·9 ± 0·3 keV are derived. Measurements have also been made on the K/L and $K/(L+M)$ ratios, which are 3·95 ± 0·25 and 3·00 ± 0·25 respectively. When compared with data on other $M4$ transitions, these results indicate that deviations from the empirical K/L curves take place at high Z. The usefulness of Bi^{207} as a test source for β-γ coincidence detectors is discussed. A.

539.165.08

1642. Method for the determination of the end-point energy of beta emitters. M. FORRO. *Phys. Rev.*, **92**, 931–3 (*Nov.* 15, 1953).

It was found that the absorption of β spectra in materials of high atomic number is exponential. The absorption coefficients in gold are inversely proportional to the $\frac{3}{2}$ power of the end-point energy of the spectrum. This experimental law holds with 2% accuracy in the energy interval from 0·3 MeV to 2·2 MeV and in the intensity domain from $\frac{1}{2}$ to 1/100 of the original intensity, if a detector with less than 2% relative opening is used. The end-point energy of β emitters can, therefore, be determined by measuring only two points on a gold absorption curve and is expressed by the equation: $E = 9\mu^{-\frac{3}{2}} + 0{\cdot}015$ with 2% accuracy from 0·17 MeV to 2·2 MeV; where E is the end-point energy in MeV and μ the absorption coefficient in cm^2/g. A.

539.165.08

1643. On the absolute measurement of beta activities. C. SÁNCHEZ DEL RÍO, O. JIMÉNEZ REYNALDO AND E. RODRÍGUEZ MAYQUEZ. *An. Real Soc. Españ. Fis. Quim.*, **48(A)**, 127–32 (*May–June*, 1952) *In Spanish.*

A new method for absolute β-counting of solid samples is given. The measurement is made with an inside Geiger–Müller tube [Abstr. 3803 (1948)] of new construction. The backscattering correction when using an "infinite" thick mounting is discussed and results for different materials given. A.

539.165.2

1644. The self-absorption of the decay electrons of In^{116} in indium metal. M. A. VIGON AND E. MONTERO. Note in *Naturwissenschaften*, **40**, *No.* 17, 458 (1953) *In German.*

The absorption curve is given and resolved into two exponentials, representing the absorption of the electrons and γ-rays separately. The absorption coefficients measured were in reasonable agreement with those calculated knowing the decay scheme of In^{116} and correcting for the counter geometry and detection efficiency. J. HUGHES

539.166

1645. On the γ-spectra of heavy nuclei. YA. I. FRENKEL. *Zh. eksper. teor. Fiz.*, **23**, *No.* 6 (12), 626–31 (1952) *In Russian.*

The γ-radiation of heavy nuclei produced by the interaction of the rotation of the nucleus as a whole and of the total spin of the nucleus are considered. It is shown that the presence of centrifugal forces, caused by the rotation of the nucleus, cannot explain the duplicity of the moment of inertia of some nuclei observed in the interpretation of the rotational γ-spectra. An assumption is introduced concerning the dissimilarity of the spin gyromagnetic ratio of the nucleus in excited states with a different spin, which permits the explanation of the multiplicity of the moment of inertia of the nucleus. E. RABKIN

539.166

1646. Angular correlations of three successive gamma quanta. J. DABROWSKI. *Bull. Acad. Polon. Sci. Cl.* **3**, **1**, *No.* 1–2, 14–17 (1953).

The general triple correlation formula for arbitrary directions of emission of the three quanta is given. The correlation coefficients are evaluated for the particular case of three dipole transitions.

J. J. WILKINS

539.166

1647. Gamma radiation emitted by oriented nuclei. The influence of preceding radiations; the evaluation of experimental data. J. A. M. COX AND H. A. TOLHOEK. *Physica*, **19**, 673–82 (*Aug.*, 1953).

The angular distribution and polarization of γ-radiation emitted by oriented nuclei was expressed earlier [Abstr. 7100 (1953)] with the aid of parameters f_k. These parameters characterize the state of orientation of the nuclei from which the radiation is emitted. Here explicit formulae are derived for the change of the parameters f_k if the γ-radiation under consideration is preceded by a β- or a γ-transition. A discussion is given of the data of physical interest, which may be obtained by the analysis of experimental data on γ-radiation from oriented nuclei: multipole character of γ-transitions, nuclear spins and parities, nuclear magnetic moments, data on the Hamiltonian for the β-interaction and nuclear matrix-elements for β-decay. A.

539.166

1648. Intensity relationship of γ-rays Xe^{131}. A. M. MIJATOVIĆ AND V. Z. WINTERSTEIGER. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3**, 57–9 (*Aug.*, 1953).

The relative intensities of the $I^{131} \rightarrow Xe^{131}$ γ-rays were determined with a NaI spectrometer. The results conform with a decay scheme given elsewhere [Abstr. 2700 (1949)]. The 722 keV transition is probably mixed $E2 + M1$. J. J. WILKINS

539.166

1649. The sequence of γ emission in triple correlations. E. J. HELLUND AND J. M. JAUCH. Letter in *Phys. Rev.*, **92**, 203 (*Oct.* 1, 1953).

It is proved that the sequence of the last two γ-rays cannot be determined by angular correlation if the last two γ-rays have the same multipole order and the final nuclear state has spin 0. J. J. WILKINS

539.166

1650. Angular correlation between the first and third gamma rays in Ti^{48}. C. E. WHITTLE AND P. S. JASTRAM. Letter in *Phys. Rev.*, **92**, 205 (*Oct.* 1, 1953).

The measured correlation is consistent with spin assignments 0, 2, 4 and 6 for the ground-state and first three excited states of Ti^{48}. J. J. WILKINS

539.166

1651. Gamma-gamma directional correlation experiments with Mo^{93m}. J. J. KRAUSHAAR. *Phys. Rev.*, **92**, 318–20 (*Oct.* 15, 1953).

Three directional correlations have been measured

involving the three successive γ-rays emitted following the 7·0 hr state in Mo^{93m}. The data characterize the spins and multipoles as

$$J+8 \xrightarrow{2^4} J+4 \xrightarrow{2^2} J+2 \xrightarrow{2^2} J,$$

which is consistent with Goldhaber's postulation on the basis of "core isomerism." A.

539.166

1652. The directional correlation and electric quadrupole interaction in the γ–γ cascade of 48·7-min Cd^{111m}. J. J. Kraushaar and R. V. Pound. Letter in *Phys. Rev.*, **92,** 522 (*Oct.* 15, 1953).

Correlation measurements for several sources differing in chemical and physical state are reported. Electric quadrupole interaction frequencies are deduced. J. J. WILKINS

539.166

1653. Angular correlation of the gamma rays from Mn^{56}. F. R. Metzger and W. B. Todd. *Phys. Rev.*, **92,** 904–6 (*Nov.* 15, 1953).

The angular correlations of the γ-rays of Fe^{56} emitted in the decay of Mn^{56} have been studied using sodium iodide scintillation counters. All three excited states of Fe^{56} involved in the decay of Mn^{56} were found to have spin 2, even parity. The spin of the ground state of Mn^{56} is probably 2, the parity even. The admixture of electric quadrupole radiation to the magnetic dipole 2–2 transitions is 2% for the 1·8 MeV γ-ray and 8% for the 2·1 MeV transition, i.e. small compared to the admixtures in other 2–2–0 cascades. A.

539.166

1654. The angular correlation of the cascade gamma rays from the decay of Au^{198}. C. D. Schrader. *Phys. Rev.*, **92,** 928–31 (*Nov.* 15, 1953).

The angular correlation of the 0·411 MeV and 0·64 MeV cascade γ-rays resulting from the β decay of Au^{198} to Hg^{198} has been measured with scintillation counters. If only pure multipole radiations are assumed, the experimental data do not agree with theoretical calculations for any reasonable values of the spins of the relevant states in Hg^{198}. They do agree well, however, with spins of 0, 2, and 2 for the ground state, 0·411 MeV state, and 1·09 MeV state of Hg^{198}, respectively, if the first transition (0·68 MeV γ) is assumed to be a mixture of 60% dipole and 40% quadrupole radiation and the second transition (0·41 MeV γ) is assumed to be pure quadrupole radiation. The parities of all three states are the same, presumably even. These results are in general agreement with the internal conversion measurements of other investigators. A.

539.166

1655. The directional correlation of the Pb^{204} γ–γ cascade. H. Frauenfelder, J. S. Lawson, Jr, W. Jentschke and G. DePasquali. *Phys. Rev.*, **92,** 1241–4 (*Dec.* 1, 1953).

The directional correlation of the Pb^{204} γ–γ cascade has been measured in chemical compounds and in a liquid Pb–Tl alloy. The values for the anisotropy of the Pb^{204} cascade in the chemical compounds vary between 0·08 ± 0·04 and 0·46 ± 0·04, thus showing a pronounced influence of extranuclear fields. The anisotropy in the liquid Pb–Tl alloy, 0·49 ± 0·05, excludes the assignment 7^- for the second excited state of Pb^{204}. The only decay scheme compatible with all experimental data requires the assignments 2^+ and 6^+ to the first and second state, respectively. The first γ transition in Pb^{204} must be a mixture of approximately 90% *E*4 and 10% *M*5. A.

539.166

1656. Gamma radiation from the decay of $^{228}_{90}Th$. J. O. Newton and B. Rose. *Phil. Mag.*, **45,** 58–62 (*Jan.*, 1954).

The energies and relative intensities of the γ-rays following the α-particle decay of Th^{228} were investigated with proportional counters. Lines were observed at 84·4 ± 0·2, 132·3 ± 1·3, 167 ± 2 and 214 ± 3 keV. The multipolarity of some of the γ-ray transitions is discussed, and two possible decay schemes are presented. A.

539.166 : 512.99

1657. A vector addition coefficient identity. R. L. Guernsey and G. B. Arfken. *Phys. Rev.*, **92,** 1270 (*Dec.* 1, 1953).

The identical results of different theoretical approaches to the angular correlation of mixed multipole γ-rays imply the existence of a vector addition coefficient identity. This is found to be a special case of a more general identity, the proof of which is outlined. A.

539.166 : 539.172.13

1658. Polarization of the gamma rays in the $F^{19}(p, \alpha\gamma)O^{16}$ reaction. L. W. Fagg and S. S. Hanna. *Phys. Rev.*, **92,** 372–7 (*Oct.* 15, 1953).

The polarizations of the 6·13, 6·9, and 7·1 MeV γ rays from the $F^{19}(p,\alpha)O^{16*}(\gamma)O^{16}$, $E_p = 0{\cdot}87$ MeV, reaction have been observed using the photodisintegration of the deuteron to detect polarization. Range measurements on the photoprotons separated the 6·13 MeV γ ray from the other two, which were only slightly resolved. Knowing the relative intensities of the 6·9 and 7·1 MeV γ rays and their unresolved angular distribution coefficient, it is possible, nevertheless, to deduce the separate polarizations from the observed total polarization. Polarization ratios, $I(0°)/I(90°)$, of 0·9 ± 0·1, 1·9 ± 0·3, and 0·4 ± 0·3 were obtained for the 6·13, 6·9 and 7·1 MeV γ rays, respectively, emitted at 90° to the proton beam. These values are in good agreement with the polarizations expected for the assignment of a 2^- state in Ne^{20} and 3^-, 2^+, and 1^- states in O^{16} as deduced by Seed and French from directional correlation measurements on this reaction. A.

539.166 : 539.172.13

1659. Gamma rays from proton bombardment of B^{10}. R. W. Krone and L. W. Seagondollar. *Phys. Rev.*, **92,** 935–7 (*Nov.* 15, 1953).

The γ-ray spectrum resulting from the radiative decay of C^{11}, produced by the proton bombardment of B^{10}, has been investigated using thick and thin targets. Observations were made for proton energies ranging from 500 keV to 1·7 MeV. A broad resonance with a maximum at 780 keV appears well established. The compound nucleus decays in a one-step transition to the ground state of C^{11} with the

emission of a γ ray of energy approximately equal to 9 MeV. The existence of two other resonances, observed for proton energies of 0·95 and 1·33 MeV, is less certain. A.

539.166 : 539.172.13

1660. Gamma radiation from the reaction $C^{13}(p, \gamma)N^{14}$. H. H. Woodbury, R. B. Day and A. V. Tollestrup. *Phys. Rev.*, **92**, 1199–206 (*Dec.* 1, 1953).

The capture radiation from $C^{13}(p, \gamma)N^{14}$ has been investigated and found to show cascade transitions which involve bound levels in N^{14} at 2·31, 3·95, 5·09, 5·81, 6·26, and 6·44 MeV in addition to the resonance levels at 8·06, 8·62, 8·70, 8·90, 8·98, 9·17, and 9·49 MeV. A.

539.166 : 539.172.4

1661. Large NaI scintillation counter study of the neutron-capture gamma-rays from hydrogen. B. Hamermesh and R. J. Culp. Letter in *Phys. Rev.*, **92**, 211 (*Oct.* 1, 1953).

A 3½ in.×3½ in. right cylinder of NaI(Tl) was used with three RCA 5819 photomultipliers placed against one face to obtain good pulse height resolution. A complete pulse-height analysis was obtained in the energy range 20 keV–3 MeV using a 20 channel analyser. Peaks occur at 2·32 MeV and 1·71 MeV, measured relative to the 2·76 γ ray from Na^{24}. The 1·71 MeV peak is caused by pair production processes from a 2·23 MeV γ ray in which one annihilation quanta escapes. No other peaks of intensity greater than 5% of the 2·23 MeV line were observed in the energy range 20 keV to 3 MeV. D. R. Chick

539.166 : 539.172.4

1662. Neutron capture γ-rays from heavy odd-charge nuclei. G. A. Bartholomew and B. B. Kinsey. *Canad. J. Phys.*, **31**, 1025–50 (*Nov.*, 1953).

The neutron capture γ-ray spectra of arsenic, niobium, rhodium, silver, indium, antimony, praseodymium, tantalum, gold, and thallium are described. The energies and intensities of the strongest high-energy γ-rays are given for each element. A.

539.166 : 539.172.4

1663. Neutron capture γ-rays from heavy even-charge nuclei. B. B. Kinsey and G. A. Bartholomew. *Canad. J. Phys.*, **31**, 1051–86 (*Nov.*, 1953).

The neutron capture γ-ray spectra of the elements selenium, strontium, zirconium, molybdenum, cadmium, tin, barium, samarium, gadolinium, wolfram, platinum, and mercury are described. The energies and intensities of the strongest high energy γ-rays are given for each element. A.

539.166.08

1664. Measurements of gamma-ray dosage in finite absorbers. E. J. Henley. *Nucleonics*, **11**, 41–3 (*Oct.*, 1953).

Al, lucite, Fe, Cu and Pb cylinders were irradiated inside a hollow tubular Co^{60} source lined inside with Al. The energy deposited in the cylinders was measured across the diameter with polyvinyl chloride dosimeters and the results compared with theoretical calculations. Energy absorption coefficients were estimated from the experimental results and found to agree well with the known values.

L. R. Shepherd

539.166.08 : 537.542

Gamma-ray energy resolution with NaI–Tll scintillation spectrometers. *See Abstr.* 1415

539.166.74

1665. The scattering of gamma-ray by nucleon and nucleon isobars. S. Minami. *Progr. theor. Phys.*, **9**, 108–16 (*Feb.*, 1953).

Assuming nucleon isobar with spin $J = 3/2$, isotopic spin $I = 3/2$ and mass $M = 1210$ MeV, the γ-ray scattering by a nucleon was studied by the covariant perturbation method. As is expected, the total cross-section varies strongly with incident γ-ray, i.e. the correction for the Klein–Nishina formula at the threshold energy for meson production is only of about 30%, but at the excitation energy of the isobar a remarkable resonance scattering is found. The angular distribution has a tendency to become predominant in the forward direction with the increase of incident energy. A.

539.166.74

1666. The elastic scattering of 1·33 MeV and 2·76 MeV gamma rays by lead. W. G. Davey. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1059–63 (*Nov.*, 1953).

A report is given of measurements of the elastic-scattering cross-section of lead for gamma-rays of 1·33 MeV and 2·76 MeV at scattering angles between 40° and 120°. With 1·33 MeV γ-rays good agreement was obtained with the theoretical predictions on the basis of Rayleigh and Thomson scattering alone. The Rayleigh scattering cross-section was calculated from Franz's formulae which are non-relativistic and based on the Thomas–Fermi approximation to the electron distribution in the atom. With 2·76 MeV γ-rays the experimental cross-sections were compared with an unpublished curve given by Bethe calculated for the K electrons alone, in addition to the values given by Franz's formulae. These theoretical curves are calculated only for Rayleigh and nuclear Thomson scattering, and at all angles in the range investigated the measured cross-sections were found to be greater than those predicted. The discrepancy is possibly due either to secondary effects, or the occurrence of Delbruck scattering. A.

539.166.74

1667. Large-angle scattering of Co^{60} gamma rays. T. D. Strickler. *Phys. Rev.*, **92**, 923–6 (*Nov.* 15, 1953).

Measurements of the scattering of Co^{60} γ-rays from lead, tin, copper, and aluminium have been made at a mean angle of 135°. In addition to Compton scattering and annihilation radiation, some higher energy components are present. Elastic scattering was observed in each of these scatterers and the cross-section for this process has been measured. Results are shown to be consistent with recent theoretical calculations on Rayleigh and Thomson scattering. A.

539.166.74

1668. Compton scattering of 2·62-MeV gamma rays by polarized electrons. S. B. Gunst and L. A. Page. *Phys. Rev.*, **92**, 970–3 (*Nov.* 15, 1953).

The differential cross-section for Compton scattering of a circularly polarized photon by an electron with given initial spin orientation can be written as a sum of the common Klein–Nishina formula for no

polarization and a term sensitive to polarization. The total cross-section is $\sigma = \sigma_0 \pm \sigma_1$. A measurement of the transmission of 2·62 MeV γ rays through iron magnetized along the transmission direction relative to that through unmagnetized iron gives the absolute value of σ_1 for this energy, if the number ν_s of polarized electrons per iron atom at saturation is known. For $\nu_s = 2{\cdot}06$, $\sigma_1/\pi r_0^2 = 0{\cdot}089 \pm 0{\cdot}007$. This agrees with the theoretical value 0·093. Alternatively, the theoretical σ_1 and the measurements would yield $\nu_s = 1{\cdot}97 \pm 0{\cdot}15$. The application of the method of this experiment to measurement of gyromagnetic ratios for ferromagnets is suggested, as is its application to the analysis of circularly polarized radiation. A.

539.166.75

1669. Attenuation of gamma rays. I. Transmission values for finite slabs of lead, iron, and the Compton scatterer. G. H. Peebles. *J. appl. Phys.*, **24**, 1272–87 (*Oct.*, 1953).

An approximate integral recursion formula is developed which gives a relation between the probability that a photon will be transmitted through a slab of finite thickness with exactly $k + 1$ collisions and the probability that it will be transmitted with exactly k collisions, where the latter probability is known for suitable ranges of slab thickness, of incident energy, and of incident angle. A similar formula also exists for the expected energy transmitted. The two recursion formulae have been used to calculate the transmissions with one, two, and three scatterings for photons incident on slabs of lead and of iron, and from these calculated transmissions the "build-up" factors have been estimated. The build-up factor for normally incident photons of 1 to 20 mc^2 are given for lead slabs and for iron slabs having a thickness of 0 to 20 m.f.p. A second method, which considers the transmission through a thick slab as a succession of transmissions through thin slabs, is used to check the estimates of the build-up factor obtained by the first method. This second method provides additional information in the form of the distributions of the transmitted photons. Finally, some transmission and reflection values for thin slabs of the Compton scatterer are presented along with some results for air which are obtained by the second (thin-slab) method. A.

539.166.75

1670. Penetration of gamma radiation through iron. L. A. Beach, R. B. Theus and W. R. Faust. *Phys. Rev.*, **92**, 355 (*Oct.* 15, 1953).

Measurements have been made on the penetration through iron by Cs^{137}, Co^{60} and Na^{24} γ radiation in plane parallel geometry. Good agreement was obtained between the experimental transmissions and theoretical values computed from Spencer's polynomial method. A.

539.166.75

1671. Degradation of gamma rays in water. M. M. Weiss and W. Bernstein. *Phys. Rev.*, **92**, 1264–5 (*Dec.* 1, 1953).

The spectra of degraded γ-rays from Co^{60} and Hg^{203} have been examined with a scintillation spectrometer, as a function of distance from the source, in an infinite water medium. The energy region below 0·150 MeV corresponding to multiple scattering was studied in greatest detail. Both the attenuation and the spectrum shape showed good agreement with the theoretical predictions of Spencer and Fano. A.

539.166.75 : 539.185.7 : 537.534.75 : 537.533.75

Penetration of radiation through a thick slab of isotropically scattering material. *See Abstr.* 1392

539.166.83

1672. Internal conversion and directional angular correlation of the Bi^{207} gammas. F. K. McGowan and E. C. Campbell. Letter in *Phys. Rev.*, **92**, 523 (*Oct.* 15, 1953).

The measurements show that 81·5% of the excited Pb^{207} nuclei emit two γ-rays in cascade, very probably according to the scheme $13/2(M4)5/2(E2)\frac{1}{2}$. This is the result expected from nuclear shell theory and lifetime considerations. J. M. CASSELS

539.166.83

1673. Internal conversion electron-gamma directional angular correlation of Bi^{207}. F. K. McGowan. Letter in *Phys. Rev.*, **92**, 524 (*Oct.* 15, 1953).

These results are consistent with those of γ–γ correlation measurements (preceding abstract). J. M. CASSELS

539.166.835

1674. On the deviation from the quadratic dependence on the atomic number of the cross-sections for pair-production. A. Z. Hrynkiewicz. *Bull. Acad. Polon. Sci. Cl.* 3, **1**, *No.* 1–2, 49–51 (1953).

Using ThC″ γ-rays and a coincidence arrangement of two G.M. counters, the ratios of the cross-sections of Al, Cu and Ag to that of Pb were measured. The results are, respectively, $0{\cdot}035 \pm 0{\cdot}003$, $0{\cdot}121 \pm 0{\cdot}009$ and $0{\cdot}306 \pm 0{\cdot}018$, which compare with expected values of 0·025, 0·125 and 0·328 for a Z^2 dependence, and 0·020, 0·104 and 0·286 for the Jaeger and Hulme theory (1936). J. J. WILKINS

539.166.835

1675. On the angular distribution of annihilation photons from electrons. Experimental study. G. Ambrosino, J. Houbaut and P. Maignan. *C.R. Acad. Sci.* [*Paris*] **237**, 708–9 (*Oct.* 5, 1953) *In French.*

The angular correlation of annihilation photons from Cu, CuO and $CuSO_4$ sources was measured in order to determine the momentum at the instant of annihilation. J. J. WILKINS

539.166.835

1676. Respective probabilities of annihilation of a positron with a 3*d* electron or a free electron in copper. J. des Cloizeaux and G. Ambrosino. *C.R. Acad. Sci.* [*Paris*] **237**, 1069–71 (*Nov.* 2, 1953) *In French.*

The mean square value of the momentum of an electron-positron system annihilating in copper is calculated, under the assumption that the electron involved is either a conduction electron, or an electron in the 3*d* shell of copper. This mean square is found to be $11{\cdot}1 \times 10^{-5}\ m^2c^2$, and falls within the limits of error of the experimental value (preceding abstract). This removes the discrepancy existing between the experimental value and the theoretical value estimated from the annihilation of positrons with free electrons in a Fermi distribution [Abstr. 7321 (1950)]. G. E. BROWN

539.166.835

1677. On the annihilation of positrons in solids. A. T. G. Ferguson and G. M. Lewis. *Phil. Mag.*, **44**, 1339–47 (*Dec.*, 1953).

Using the method of delayed coincidences the lifetimes of positrons from Na^{22} have been determined in various materials, the 1·28 MeV γ-ray of Na^{22} announcing the emission of a positron. A lifetime of $(1{\cdot}6 \pm 0{\cdot}6) \times 10^{-10}$ sec has been deduced in aluminium, and comparative measurements show that it does not differ from this in other metals studied by the authors and by other writers. A second lifetime of $(2{\cdot}5 \pm 0{\cdot}3) \times 10^{-9}$ sec involving 0·27 ± 0·03 of the positrons has been found in distrene at room temperature. This lifetime has been found to increase by about 10% for 115°C rise in temperature. Three-quantum emission from distrene has been found to be small. Experiments have also been carried out in plastic sulphur and magnetized iron. A.

539.167.3

1678. Production of radioisotopes. A. F. Rupp and F. T. Binford. *J. appl. Phys.*, **24**, 1069–81 (*Sept.*, 1953).

Problems involved are outlined. Chemical processing details for C^{14}, P^{32}, I^{131}, S^{35}, Ca^{45} and certain fission products are given. The radioisotope processing facilities at the Oak Ridge National Laboratory are described. Half lives, production methods, specific activities attainable at ORNL and principal methods of purification of a number of radioisotopes are tabulated. L. R. Shepherd

539.167.3

1679. Comparative retentions of the nuclear isomers of Br^{80} in the propyl bromides. P. C. Capron and E. Crèvecoeur. *J. chem. Phys.*, **21**, 1843–50 (*Oct.*, 1953).

Experiments on retention, which is defined as the fraction of the radioactivity resisting aqueous extraction, gave for propyl bromides irradiated in paraffin at a distance of two centimeters from the source with unfiltered neutrons:

	$R_{[Br^{80}(18\ min)]}$	$R_{[Br^{80}(4\cdot4\ hr)]}$
Normal propyl bromide	0·72 ± 0·05	0·85 ± 0·05
Isopropyl bromide	0·37 ± 0·02	0·58 ± 0·03

The different sources of error are examined and eliminated. The addition of free bromine, with the purpose of blocking the impurities, left a difference in the retention of the two isomers. An interpretation is suggested. The percentage of Br(18 min) of isomeric transition in the free state proceeding from Br(4·4 hr) in the bound state, is found to be 16% for the normal propyl bromide and 40% for the isopropyl bromide. A.

NUCLEAR REACTIONS 539.17

539.17

1680. The use of tensor operators in nuclear collision problems. L. Wolfenstein. *Phys. Rev.*, **92**, 123–5 (*Oct.* 1, 1953).

The consequences of the invariance under rotations and reflections of the collision matrix are expressed as a relationship between the expectation values of initial-state and final-state irreducible tensor operators in spin-orbit space. This relationship is used to give a proof of the Eisner–Sachs theorem on the complexity of angular distributions of nuclear reactions and some extensions of this theorem. A.

539.17

1681. Theory of polarized particles and gamma rays in nuclear reactions. A. Simon. *Phys. Rev.*, **92**, 1050–60 (*Nov.* 15, 1953).

The complete specification of the spin states of a particle of spin i resulting from a nuclear reaction requires a knowledge of all irreducible spin tensor moments $T^q_\chi(|\kappa| \leq q \leq 2i)$. A general calculation is made of the spin tensor moments arising from a nuclear reaction initiated by an arbitrarily polarized initial beam. All sums over magnetic quantum numbers are performed by the use of the S-matrix and Racah formalisms. The results are expressed in terms of the G function which is related to the Fano X function. All selection rules follow from the properties of the G function. In particular, a generalization of the Eisner–Sachs selection rules are given. The problem of the detection of polarized particles is considered. The S-matrix formalism is extended to include the possibility of γ-rays in nuclear reactions. Analogous formulae to those of Blatt and Biedenharn are given for the angular distribution of γ-rays. A simple recipe yields a general result for the polarization and angular distribution of radiation from aligned nuclei. Finally, the theory is extended to include the possibility of an arbitrarily polarized target nucleus as well. A.

539.17

1682. The statistical theory of nuclear reactions. B. L. Cohen. *Phys. Rev.*, **92**, 1245–8 (*Dec.* 1, 1953).

It is pointed out that the discrepancies between experimental results and the predictions of the statistical theory of nuclear reactions can be traced to peculiarities in the energy distribution of particles emitted in the break-up of the compound nucleus. Experimental energy distributions are analysed, and it is shown that very strange assumptions—susceptible to experimental check—are necessary to explain them in any way without the introduction of a new selection rule in nuclear transitions. Experiments are suggested to clarify these problems. A.

539.172 : 537.591.8

Nuclear reactions due to cosmic rays. *See Abstr.* 1451.

539.172

1683. Splitting of a fast carbon nucleus in the collision with a hydrogen nucleus in the nuclear emulsion. B. Dobovišek. Letter in *Bull. sci. Cons. Acad. Yougoslavie*, **1**, 38–9 (*July*, 1953).

The event was observed in a G5 plate exposed at an altitude of 30 km. A proton recoil track and four additional tracks due to fragments of the carbon nucleus (2 α-particles and 2 protons) emerge from the star. H. Elliot

539.172

1684. Radioactive copper nuclides produced by slow negative pions and muons from zinc. A. Turkevich and S.-C. Fung. Letter in *Phys. Rev.*, **92**, 521 (*Oct.* 15, 1953).

The copper nuclides were produced by reactions of

the type $Zn(\mu^-, yn)$ and $Zn(\pi^-, xn)$. It was found that y is slightly greater than 1 and x lies between 2 and 3. J. M. CASSELS

539.172

1685. Interaction of negative pions with mercury. N. SUGARMAN AND A. HABER. *Phys. Rev.*, **92**, 730–4 (*Nov.* 1, 1953).

Radiochemical separation of expected fission products from mercury irradiated with 122 MeV π^- mesons demonstrates that fission occurs. The fission products are distributed in yield similar to those from the fission of mercury by high-energy neutrons. The branching ratio for meson fission is about 0·5%. Thallium activities found in the meson-irradiated mercury are explained as produced by secondary fast protons. A.

539.172

1686. Positive pi-meson interactions in beryllium. F. H. TENNEY AND J. TINLOT. *Phys. Rev.*, **92**, 974–7 (*Nov.* 15, 1953).

A 10 in. dia. magnet cloud chamber containing a ¼ in. Be plate has been operated in both the 40 MeV and 50 MeV π^+-meson beams of the Rochester 130 in. cyclotron. Meson interactions in Be were obtained for three bands of energy: 15 to 30 MeV, 25 to 40 MeV and 35 to 50 MeV. The events recorded as nuclear interactions were: stars, stops and scatterings of greater than 30 degrees. From a survey of some 22 700 g/cm² of Be traversed, a total of 159 such events were found. Analysis of the data from each energy band indicates the absorption cross-section to be energy dependent. The ratio of corrected stars to corrected scatterings was found to be roughly 2 : 1. A.

539.172

1687. Angular and energy distributions in energetic pion interactions with nuclei. A. H. MORRISH. *Phil. Mag.*, **45**, 47–57 (*Jan.*, 1954).

A total of 405 events due to the interaction of 210 ± 20 MeV π^--mesons with the nuclei of photographic emulsion are analysed. Angular and energy distributions of the charged reaction products are interpreted as giving evidence of a cascade process for those events in which the meson survives. The characteristics of the remaining events, in which the meson is either absorbed or undergoes charge exchange, are primarily determined by the evaporation process. A.

539.172 : 539.18

Negative μ-meson capture in carbon. *See Abstr.* 1743

539.172.11

1688. A study of the (αp)-reaction in nitrogen by means of photographic emulsions. E. HJALMAR AND H. SLÄTIS. *Ark. Fys.*, **6**, *Paper* 43, 451–62 (1953).

A survey is given of earlier investigations concerning the $N^{14}(\alpha, p)O^{17}$ reaction, and the energy of the first excited level in O^{17} as determined from other reactions. Using nuclear research emulsions two proton groups from the (α, p) reaction in nitrogen, with $Q = -1{\cdot}16$ and $-2{\cdot}0$ MeV, respectively, have been observed. The energy distribution of the elastically scattered protons originating in (α, p) recoils in the mica window of the polonium source was estimated theoretically. The result was in close agreement with the experimentally measured energy distribution. The energy distributions of the α-particles from ThC and ThC′ were studied by means of nuclear research plates, and the energies found were compared with the spectrometer results obtained by Lewis and Bowden. Improvements in the emulsion technique method are suggested. A.

539.172.11

1689. Determination of the widths of the levels of p^{31} from the reaction $^{27}Al(\alpha, p)^{30}Si$. R. R. ROY AND C. GODEAU. Letter in *Phil. Mag.*, **44**, 1184–6 (*Oct.*, 1953).

A diffusion cloud chamber was used at the resonant bombarding energies of 4 MeV and 4·4 MeV, the source being polonium. Only the proton group with $Q = 1{\cdot}32$ MeV was studied. The width of the 14·3 MeV level in the compound nucleus p^{31} was deduced from the frequency distribution of the range of 107 proton tracks as 0·36 ± 0·06 MeV; similarly the width of the 14·8 MeV level was deduced from 85 proton tracks as 0·30 ± 0·06 MeV.

D. R. CHICK

539.172.11

1690. Energy levels in F^{18} from alpha particle reactions in nitrogen. N. P. HEYDENBURG AND G. M. TEMMER. *Phys. Rev.*, **92**, 89–92 (*Oct.* 1, 1953).

The elastic scattering of α particles in nitrogen as a function of the energy between 1·5 and 3·5 MeV at 90°, 125° 16′, 137° 43′ and 156° 20′ (centre of mass), and the cross-section for the $N^{14}(\alpha, p)O^{17}$ reaction at 90° (lab) in the same energy region were examined. Two new resonances at $E_\alpha = 2{\cdot}935$ MeV and $E_\alpha = 3{\cdot}140$ MeV correspond to levels in F^{18} at excitation energies of 6·69 MeV and 6·85 MeV, respectively. These same levels were found to emit protons as well, leading to the ground state of O^{17}. The (α, p) reaction has a relative probability of about 5% for the upper level and 0·3% for the lower level, compared to the elastic scattering. A.

539.172.13

1691. On the reaction $^{18}O(p, \alpha)^{15}N$. R. R. ROY, A. LAGASSE AND M. J. DECOCK. Letter in *Phil. Mag.*, **44**, 1189–91 (*Oct.*, 1953).

The γ-ray yield shows a nearly linear increase for proton energies between 400 and 700 keV. Although a resonance on the α yield occurs at a bombarding energy of 640 keV, no resonance was observed in the γ-ray yield at this proton energy. It is thus concluded that no excited level is formed in N^{15} for the reaction $O^{18}(p\alpha)$ N^{15} at the resonance energy of the proton 640 keV and that the compound nucleus F^{19} decays with the emission of one group of α particles leaving the final nucleus N^{15} in the ground state.

D. R. CHICK

539.172.13

1692. The excitation function for the reaction $^9Be(p, p2n)^7Be$. D. C. SALTER AND L. BIRD. Letter in *Phil. Mag.*, **44**, 1305–6 (*Nov.*, 1953).

The cross-section has been measured from 33 to 155 MeV. J. M. CASSELS

539.172.13

1693. The angular distribution of the α-particles from the $^7Li(p, \alpha)$ reaction. D. K. Cartwright, L. L. Green and J. C. Willmott. Letter in *Phil. Mag.*, **44**, 1307–8 (*Nov.*, 1953).

The coefficients of both the $\cos^2\theta$ and the $\cos^4\theta$ terms were determined at 610, 710 and 800 keV.

J. M. CASSELS

539.172.13

1694. Inelastic scattering of protons and deuterons from B^{10} and N^{14}. C. K. Bockelman, C. P. Browne, W. W. Buechner and A. Sperduto. *Phys. Rev.*, **92**, 665–9 (*Nov.* 1, 1953).

Proton and deuteron groups scattered from B^{10} and N^{14} targets were measured with a magnetic spectrograph. Accurate values for the level positions up to approximately 5 MeV excitation were obtained. One level in each nucleus failed to scatter deuterons. The operation of an isobaric spin-selection rule seems to be the most reasonable explanation of this behaviour.

A.

539.172.13

1695. Production of neutral mesons by 340-MeV protons on hydrogen. J. W. Mather and E. A. Martinelli. *Phys. Rev.*, **92**, 780–9 (*Nov.* 1, 1953).

The production of neutral mesons by 340-MeV protons on hydrogen has been measured directly by detecting a single γ-ray from the two γ-ray decay of a neutral meson, at 90° to the proton beam. A liquid hydrogen target and a focusing Cherenkov counter are described. The ratio of the cross-section for neutral meson production from hydrogen relative to carbon is $\sigma_H/\sigma_C = 0{\cdot}0059 \pm 0{\cdot}0009$, where the error is standard deviation. Using the absolute cross-section of neutral meson production from carbon as $1{\cdot}5\times10^{-27}$ cm^2, one obtains the neutral meson production cross-section for hydrogen to be $8{\cdot}8\times10^{-30}$ cm^2. The transition $^3P \rightarrow {}^1S$ (allowed by the conservation of angular momentum and parity) for the protons can be interpreted as a triplet p-state interaction with emission of an s-state neutral meson. The agreement with the existing data at proton energies of 440 MeV is fair. The 340- and 440-MeV data give two points on the neutral meson excitation function curve, showing a steep rise. The experimental results give some evidence for the breakdown of the approximate selection rule which forbids the emission of s-state neutral mesons with final s-state nucleons. The relative cross-section for carbon and nitrogen indicates that the yield of neutral mesons is due to the interaction of the incident protons with the neutrons in the nuclei.

A.

539.172.13

1696. The nuclear disintegrations produced by high energy protons. G. C. Morrison, H. Muirhead and W. G. V. Rosser. *Phil. Mag.*, **44**, 1326–38 (*Dec.*, 1953).

A comparison is made between the nuclear disintegrations observed when 140 MeV protons pass through photographic emulsions and the nature of the disintegrations expected on the Goldberger model [Abstr. 1178 (1949)]. Satisfactory agreement is found for all the features of the disintegrations examined.

A.

539.172.13

1697. Preliminary note on the angular distribution from $Be^9(d, t)Be^8$. M. K. Jurić and B. S. Maršičanin. *Bull. Inst. Nuclear Sci. "Boris Kidrich,"* **3**, 139–40 (*Aug.*, 1953).

1·16 MeV deuterons were used to bombard a thin beryllium target set at 45° to the beam. The camera covered the range 0–170° at 10° intervals, the average angle of incidence of the particles in the 100 μ, C2 emulsion was 10°. Four particle groups were observed and the angular distribution for the tritons from $Be^9(d, t)$ Be^8 and for the protons from $Be^9(d, p)$ Be^{10} were measured.

D. R. CHICK

539.172.13

1698. An approximate wave-mechanical description of deuteron stripping. F. L. Friedman and W. Tobocman. *Phys. Rev.*, **92**, 93–100 (*Oct.* 1, 1953).

An approximate wave function describing the deuteron stripping process is set up in a fashion similar to that introduced by S. T. Butler [Abstr. 8973 (1951)]. This wave function is made to fit boundary conditions at the surface of the nucleus for the stripped-off particle. Thus the parameters characterizing the nucleus that enter this description are similar to those familiar from the theory of single-particle nuclear reactions. The cross-section for the stripping process is calculated from the wave function by a method that gives the cross-section for stripping by virtual levels as well as that for stripping by bound levels. Some discussion is devoted to the Coulomb effect.

A.

539.172.13

1699. Magnetic analysis of the $V^{51}(d, p)V^{52}$ reaction. J. E. Schwager and L. A. Cox. *Phys. Rev.*, **92**, 102–4 (*Oct.* 1, 1953).

The proton groups from vanadium targets bombarded with 6 MeV deuterons from an electrostatic generator have been analysed with a 180-degree magnetic spectrograph. The ground-state Q value for the $V^{51}(d, p)V^{52}$ reaction was found to be $5{\cdot}072 \pm 0{\cdot}008$ MeV. Of the proton groups observed, twenty-three have been ascribed to vanadium and correspond to excited states in V^{52} between the ground state and an excitation energy of 3·30 MeV.

A.

539.172.13

1700. Protons from the deuteron bombardment of Kr^{84} and Kr^{86}. G. W. Wheeler, R. B. Schwartz and W. W. Watson. *Phys. Rev.*, **92**, 121–3 (*Oct.* 1, 1953).

Samples of krypton gas enriched to 70·5% in Kr^{84} and to 82·0% in Kr^{86} have been prepared by a thermal diffusion method. These samples have been bombarded with 3·80 MeV deuterons from the Yale cyclotron. Q values of $3{\cdot}72 \pm 0{\cdot}05$ MeV and $3{\cdot}43 \pm 0{\cdot}05$ MeV are observed for the ground state and first excited state of Kr^{85}. Q values of $3{\cdot}30 \pm 0{\cdot}05$ MeV and $2{\cdot}78 \pm 0{\cdot}05$ MeV are observed for the ground state and first-excited state of Kr^{87}. The masses of Kr^{85} and Kr^{87} are $84{\cdot}94090 \pm 13$ and $86{\cdot}94125 \pm 12$.

A.

539.172.13

1701. Excited states of B^{11} and B^{12} from the reactions $B^{10}(d, p)$ B^{11} and $B^{11}(d, p)B^{12}$. M. M. Elkind. *Phys. Rev.*, **92**, 127–33 (*Oct.* 1, 1953).

Evaporated targets of natural boron and enriched

B^{10} deposited on thin Formvar films were bombarded with deuterons produced by the MIT–ONR Van de Graaff accelerator. Incident energies from 4·0 to 8·5 MeV were used, and charged particles leaving the target at 90 degrees to the deuteron beam direction were analysed by a 180 degree magnetic spectrograph. The studies covered a region of excitation from 7·50 to 11·46 MeV in B^{11}, and from zero to 3·40 MeV in B^{12}. In the case of B^{11}, two new groups have been found in addition to those previously reported. These have excitation energies of 7·987 ± 0·014 MeV and 10·32 ± 0·02 MeV; the former level is paired with the 7·39 MeV level in C^{11}. The width of the 10·32 MeV level is noticeably broad, 54 ± 17 keV, whereas all the other boron levels detected in this work had widths less than 10 keV. The new levels in B^{12} found by (d, p) reaction have excitation energies of 1·674 ± 0·011, 2·618 ± 0·011, 2·723 ± 0·011, and 3·383 ± 0·009 MeV. An analysis of the presently known properties of C^{12} levels lying in the excitation region corresponding to the first five levels in B^{12} suggests the possibility that most of these C^{12} levels have a total isotopic spin of 1. A.

539.172.13

1702. The neutron spectrum from the $O^{18}(d, n)F^{19}$ reaction. R. L. Seale. *Phys. Rev.*, **92**, 389–90 (*Oct.* 15, 1953).

The neutron spectrum from the $O^{18}(d, n)F^{19}$ reaction has been investigated. $BaCO_3$ targets enriched in O^{18} were bombarded with 2 MeV deuterons and the emitted neutrons were detected using 100- and 200-micron Ilford nuclear plates. The method of analysing the data is discussed in detail. The results of the experiment indicates the presence of 4 excited levels in the F^{19} which had not been previously reported. These levels are at 0·9 MeV, 2·2 MeV, 5·2 MeV, and 5·5 MeV. A.

539.172.13

1703. Theory of high-energy deuteron pick-up. B. J. Malenka. Letter in *Phys. Rev.*, **92**, 516 (*Oct.* 15, 1953).

The deuteron pick-up scattering amplitude is determined with the help of the standard stationary state Green's function technique [E. Gerjuoy, Abstr. 7922 (1953)], neglecting the energy exchanged with the residual nucleus as well as spin and Coulomb effects. W. A. Hepner

539.172.13

1704. The 7·68-MeV state in C^{12}. D. N. F. Dunbar, R. E. Pixley, W. A. Wenzel and W. Whaling. *Phys. Rev.*, **92**, 649–50 (*Nov.* 1, 1953).

Magnetic analysis of the α-particle spectrum from $N^{14}(d, \alpha)C^{12}$ covering the excitation energy range from 4·4 to 9·2 MeV in C^{12} shows a level at 7·68 ± 0·03 MeV. At $E_d = 620$ keV, $\theta_{lab} = 90°$, transitions to this state are only 6% of those to the level at 4·43 MeV. A.

539.172.13

1705. An investigation of (d, p) stripping reactions. V. Results for some of the light elements and conclusions. J. R. Holt and T. N. Marsham. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1032–40 (*Nov.*, 1953).

For Pt IV, see Abstr. 7127 (1953). Angular distribution measurements have been carried out on proton groups emitted under bombardment by 8 MeV deuterons from targets of Li^6, Li^7, Be^9, B^{10} and B^{11}. The theory of the stripping process has been applied to determine in each case the orbital angular momentum l of the captured neutron. In the following list the values of l are shown in brackets after the excitation energy of the product nucleus (in MeV): $Li^6 \rightarrow Li^7$, ground state (1), 0·478(1); $Li^7 \rightarrow Li^8$, ground state (1); $Be^9 \rightarrow Be^{10}$, ground state (1); $B^{10} \rightarrow B^{11}$, ground state (1); $B^{11} \rightarrow B^{12}$, ground state (1), 0·95(1), 1·67(0), 3·38(1), 4·53(2). Similar measurements have been made on triton groups from Li^7 and Be^9 and the results compared with the theory of Newns [Abstr. 1910 (1953)]. The results of this and previous work on stripping are discussed. A.

539.172.13

1706. Angular distribution of γ-radiation following a deuteron stripping reaction. G. R. Satchler. *Proc. Phys. Soc.* [*London*] *A*, **66**, 1081–92 (*Dec.*, 1953).

The angular distribution of γ-radiation from a deuteron stripping reaction is given as a Legendre series $W(\theta) = \Sigma_\nu A_\nu P_\nu(\cos\theta)$. The coefficients are given in terms of the total angular momentum (orbital plus spin) of the captured nucleon and fully tabulated. Analysis of observed distributions can then test j–j shell model assumptions. Cascades are discussed and a general theorem for the angular distribution of the nth radiation of a cascade is stated in an appendix. Formulae are given relating the parameters of this paper to those used in the channel spin formulation. Their values when the nuclei obey L–S coupling rules are also given. Some other applications of the theory are indicated and results of interest to experimentalists are summarized. A.

539.172.13

1707. The radionuclides of arsenic produced by deuteron bombardment of germanium. H. F. Watters and J. F. Fagan, Jr. *Phys. Rev.*, **92**, 1248–9 (*Dec.* 1, 1953).

The arsenic produced by a deuteron bombardment of germanium has been studied to determine the nuclides present in the mixture. Identification of the isotopes was made by comparing measured values of half-life and maximum β energy with published values. Counting rates were measured with 4π and coincidence counters, obtaining half-lives which indicated that the nuclidic mixture was made up of As^{71}, As^{72}, As^{73}, As^{74}, and As^{77}. These findings were confirmed by maximum β energy values obtained by absorption measurements and by γ-energy values found using a γ-ray scintillation spectrometer. Measurements indicated that the 40 hr half-life reported for As^{77} is in error by a significant amount, and that no As^{76} was obtained from this bombardment. Thick target yield data were determined for each nuclide from the 4π counter measurements. A.

539.172.13

1708. Interaction of 19-MeV deuterons with oxygen. R. G. Freemantle, W. M. Gibson, D. J. Prowse and J. Rotblat. *Phys. Rev.*, **92**, 1268–9 (*Dec.* 1, 1953).

The charged particles emitted when oxygen is bombarded with 19 MeV deuterons have been studied by a photographic plate method. The angular distributions of the two groups of protons from the reaction

$O^{16}(d, p)O^{17}$, O^{17} being formed in the ground and 0·88 MeV states, have been found to be in qualitative agreement with the predictions of the stripping theory. Similar measurements have been made for the elastically scattered deuterons and for the α-particles from the reaction $O^{16}(d, \alpha)N^{14}$; the curve for the latter shows peaks at about 40°, 90°, and 140°, and is nearly symmetrical about 90°. A.

539.172.13

1709. Energy spectrum of protons produced in the reaction $C^{12}(d, p)C^{13}$, and its relation with the possible excited states of C^{13}. III. J. Catalá, F. Senent and J. Aguilar. *An. Real. Soc. Españ. Fis. Quim.*, **48**(A), 73–80 (*March–April*, 1952) *In Spanish.*

For Pt II, see Abstr. 2979 (1952). Concludes the study of the C^{13} energy levels, dealing with the results obtained between 4 MeV and 8·5 MeV, checking the existence of some more excited states than those usually mentioned. A.

539.172.13

1710. A study of the $H^3 + He^3$ reactions. C. D. Moak. *Phys. Rev.*, **92**, 383–8 (*Oct.* 15, 1953).

The reactions $H^3(He^3, d)He^4$, $H^3(He^3, p)He^5$ and $H^3(He^3, p)He^4, n^1$ have been studied in the 100 keV to 800 keV region of bombarding energy. In the case of $H^3(He^3, p)He^5$, the proton energy was measured with a scintillation spectrometer; from this measurement, the energy of break-up of He^5 into a neutron and an α-particle was found to be 0·95 ± 0·07 MeV. At a bombarding energy of 360 keV, the deuterons from the $H^3(He^3, d)He^4$ were found to be isotropic in the centre-of-mass system. The spectrum of protons from the three-body break-up, $H^3(He^3, p)He^4, n^1$, was found to be flat within experimental error from 2 to 8 MeV. Competitions among the various modes of decay of the compound nucleus of Li^6 do not vary beyond an experimental uncertainty of ±2% from 200 keV to 600 keV bombarding energy. The shape of the total cross-section curve, measured from 100 keV to 800 keV, appears to indicate a non-resonant behaviour, similar to the case of the *d–d* reaction. A.

539.172.3

1711. Photodisintegration of the deuteron at high energies. B. Bruno and S. Depken. *Ark. Fys.*, **6**, *Paper* 19, 177–89 (1953).

This is treated in the energy range 80 to 250 MeV. Processes involving the exchange of virtual mesons are taken into account and shown to give important contributions. Total cross-sections and angular distributions are discussed, and comparison is made with recent experimental results. A.

539.172.3

1712. The quadrupole transition in the photodisintegration of the deuteron. H. Überall and F. Schlesinger. *Acta phys. Austriaca*, **7**, *No.* 4, 355–64 (1953) *In German.*

The cross-section of the electric quadrupole transition is calculated. For small energies this is a small correction to the dipole cross-section. At about 55 MeV the cross-sections are comparable, but above 60 MeV the quadrupole cross-section again falls off in comparison with that for the dipole.

P. T. MATTHEWS

539.172.3

1713. Some remarks on the photodisintegration of deuteron. II. J. Fujimura. *Progr. theor. Phys.*, **9**, 132–6 (*Feb.*, 1953).

For Pt I, see Abstr. 3596 (1953). Electric interactions in high energies are investigated on the photodisintegration of the deuteron. The contributions of the proton current and the exchange effect are separately studied. It is found that the single particle approximation is not necessarily valid in the process. The angular distribution of this process, in which exchange magnetic interaction is also taken into account, is presented. It shows a fair agreement with the experimental data. A.

539.172.3

1714. Photo-production of mesons in nuclei. W. Thirring. *Helv. phys. Acta*, **26**, *No.* 5, 465–88 (1953) *In German.*

Without the use of a meson theory a study is made of the photo-production in nuclei by relating it to empirical information on production on single nucleons and meson absorption in nuclei. Three assumptions about the momentum distribution of nucleons are studied: $(1 + p^2)^{-1}$, e^{-p^2}, Fermi distribution. The available experimental material on energy and angular distributions can be accounted for with e^{-p^2}. W. J. SWIATECKI

539.172.3

1715. Theory of photonuclear reactions. C. Mercier and A. Herpin. *C.R. Acad. Sci.* [*Paris*] **237**, 556–8 (*Sept.* 14, 1953) *In French.*

By expressing the probability for compound-nucleus formation in terms of a complex potential, a formula for the total cross-section has been derived, giving correctly the magnitude, dependence on photon energy and dependence on atomic number.

J. J. WILKINS

539.172.3

1716. The cross section for $^{181}Ta(\gamma, n)^{180}Ta$ at 17·6 MeV. J. H. Carver and H. J. Hay. Letter in *Phil. Mag.*, **44**, 1191–3 (*Oct.*, 1953).

The ratio of the cross-section at 17·6 MeV to that at 14·6 MeV has been measured, using $Li^7(p, \gamma)$ radiation, with the result 0·26 ± 0·06. This agrees with results obtained using bremsstrahlung [Abstr. 2993 (1952)]. J. J. WILKINS

539.172.3

1717. Charge independence in (γ, n) and (γ, t) reactions. D. C. Peaslee and V. L. Telegdi. *Phys. Rev.*, **92**, 126–7 (*Oct.* 1, 1953).

The comparison of (γ, n) and (γ, t) reactions on light nuclei with $A = 4n + 3$ will give information on charge symmetry *v.* charge independence for nuclear forces. If isotopic spin is a good quantum number (charge independence), more individual levels should appear in (γ, n) reactions than in (γ, t); those peculiar to (γ, n) have $T = \frac{3}{2}$, the others have $T = \frac{1}{2}$. The one presently measured case of Li^7 favours charge independence. A.

539.172.3

1718. Matrix elements for the nuclear photoeffect. L. L. Foldy. *Phys. Rev.*, **92**, 178–88 (*Oct.* 1, 1953).

A phenomenological formulation of the interaction

of nuclear systems with the transverse electromagnetic field is developed, and expressions for the nuclear photoeffect matrix elements are obtained. The development is based on the differential charge conservation law and the hypothesis that the charge and current density operators for a nuclear system can be expressed in terms of nucleon variables only, even though virtual mesons may play a role in the interaction of the system with the electromagnetic field. The charge and current density operators are expressed as the sum of one-particle, two-particle, etc., terms in analogy with the phenomenological treatment of potential interactions between nucleons. The treatment is sufficiently general to include velocity dependence of interaction charges and currents, but is essentially nonrelativistic. Methods of explicitly constructing the most general forms of the charge and current density operators are given, taking into account general invariance and symmetry conditions to which they are subject. A new feature found in the present treatment is the possible existence of interaction effects in the charge density operator which imply that long-wavelength electric dipole matrix elements can be affected by interactions between nucleons (contrary to recent statements in the literature). The effects of the principles of charge symmetry and charge independence on nuclear-electromagnetic interactions are discussed. The form in which the photoeffect matrix elements are presented is such as to allow computation of all multipoles in an already summed form. A.

539.172.3

1719. Systematics of photoneutron reactions. R. Nathans and J. Halpern. Letter in *Phys. Rev.*, **92**, 207 (*Oct.* 1, 1953).

Photoneutron cross-sections have been measured for 13 elements, from C^{12} to U^{238}, by direct detection of the neutrons. The significant parameters (widths, etc.) of the cross-section resonances are reported and discussed. J. J. WILKINS

539.172.3

1720. Photoprotons from In, Ce, and Bi. M. E. Toms and W. E. Stephens. *Phys. Rev.*, **92**, 362–6 (*Oct.* 15, 1953).

The charged particles ejected from indium, cerium and bismuth foils by X-rays from a 24 MeV betatron were observed in nuclear emulsions. The yields of photoprotons, photodeuterons and photoalpha-particles were determined, and the energy and angular distributions of the photoprotons were measured and compared with theoretical calculations based on the evaporation process and on the direct photo effect. The energy distributions observed indicate a large fraction of direct photo effect. A marked forward asymmetry was observed in the angular distributions from indium and bismuth. A.

539.172.3

1721. The production of protons from carbon by monoenergetic gamma rays. J. W. Weil and B. D. McDaniel. *Phys. Rev.*, **92**, 391–400 (*Oct.* 15, 1953).

A technique is described for selecting from the interactions produced by a bremsstrahlung spectrum only those arising from essentially monoenergetic quanta. These interactions are selected by requiring a coincidence with the degraded electron which produced the interacting quanta. A study of the photoproduction of protons from carbon was made using 190 MeV monochromatic quanta from the 310 MeV Cornell synchrotron. An energy distribution of the emitted protons was observed at 60 degrees and an angular distribution of 70 MeV protons was also obtained. Interpretation of these results in terms of a deuteron model gives satisfactory agreement and indicates that the photoproduction process involves only a few nucleons on the average and probably involves just two nucleons a large fraction of the time. Rough quantitative agreement is obtained with experiments on the photodisintegration of the deuteron. A.

539.172.3

1722. The reaction $C^{12}(\gamma, 3p)Li^9$. D. Reagan. *Phys. Rev.*, **92**, 651–2 (*Nov.* 1, 1953).

A carbon target was bombarded in a partially-converted 270 MeV electron beam. The 0·168 sec Li^9 delayed neutron activity produced in the block was compared with the β-activity produced in a polystyrene foil bombarded in the same beam. The measured integrated cross-section for $C^{12}(\gamma, 3p)Li^9$ is $(7{\cdot}2 \pm 2) \times 10^{-5}$ MeV barns. A.

539.172.3

1723. Excitation function for the photodisintegration of beryllium. R. Nathans and J. Halpern. *Phys. Rev.*, **92**, 940–1 (*Nov.* 15, 1953).

Using filtered betatron bremsstrahlung, the $Be^9(\gamma, n)$ excitation function has been determined from threshold to 24 MeV. The results show two peaks, one due to excitation of the odd neutron and the second to the excitation of the Be^8 core. A.

539.172.3

1724. Angular and energy distributions of photoprotons from aluminum and tantalum. M. M. Hoffman and A. G. W. Cameron. *Phys. Rev.*, **92**, 1184–91 (*Dec.* 1, 1953).

Foils of aluminium and tantalum were irradiated at energies from 25 to 65 MeV in the X-ray beam of the Iowa State College synchrotron. Photoprotons produced at various angles were recorded in nuclear emulsions. Those emitted with low energies appear isotropically distributed and have energy distributions characteristic of statistical evaporation processes. The higher-energy protons from aluminium have an angular distribution of the form $(\sin\theta + p \sin\theta \cos\theta)^2$ with $p \simeq 0{\cdot}7$, whereas those from tantalum have a nearly pure $\sin^2\theta$ distribution. Their energy distributions can be represented in the form E_p^{-n}, where E_p is the proton energy. For aluminium, sharp increases in the exponent n occur at a value of E_p slightly greater than half the maximum photon energy of the irradiation. The increases are considerably less in the case of tantalum. The aluminium results are qualitatively consistent with Levinger's quasi-deuteron model of the nucleus. None of the proposed photon interaction models gives a good explanation of the tantalum results. A.

539.172.3 : 545.83

An analysis for deuterium based on the photoneutron effect. *See Abstr.* 1833

539.172.4

1725. On the application of the nuclear emulsion method to the determination of the absorption coefficients of slow neutrons. M. Wielowiejska. *Bull. Acad. Polon. Sci. Cl.* 3, **1**, *No.* 1–2, 60–2 (1953).

A radium-beryllium neutron source, a paraffin wax moderator and Li-loaded emulsion detectors were used for slow neutron total cross-section measurements. The cross-sections of Pb and Al so measured agree well with those obtained by other methods.

J. M. CASSELS

539.172.4

1726. The capture cross-section of C^{13} for thermal neutrons, and a method of determining N by means of activation. E. Broda and G. Rohringer. *Naturwissenschaften*, **40**, *No.* 12, 337–8 (1953) *In German.*

Activity measurements on CO_2 from paraffin wax irradiated for 480 hours by a stream of thermal neutrons (2×10^{11} cm^{-2} sec^{-1}) yielded ~ 360 decays of C^{14} per g instead of ~ 3600 calculated for a capture cross-section of C^{13} equal to 10^{-25} cm^2. It is concluded that the true capture cross-section must be $\leqslant 10^{-26}$ cm^2. While the Szilard–Chalmers effect cannot be determined in this case because of the interference of N^{14} with its large capture cross-section, it becomes possible to determine analytically small amounts of N in the presence of C. The activation cross-section ratio has been found to be $\geqslant 17\,000$ for natural N/natural C.

F. LACHMAN

539.172.4

1727. Angular distribution of neutrons scattered from aluminum, iron, and lead. W. D. Whitehead and S. C. Snowdon. *Phys. Rev.*, **92**, 114–19 (*Oct.* 1, 1953).

The differential cross-sections for the scattering of 3·7 MeV neutrons from aluminium, iron and lead have been measured in a ring geometry using a moulded Lucite-ZnS button as a detector. The measurements were taken over an angular range of 127° between 13° and 140° with an angular resolution better than ±10°. Effects due to higher-order scattering in the scatterer were removed by extrapolation.

A.

539.172.4

1728. Total neutron cross section of liquid argon. J. B. Guernsey and C. Goodman. *Phys. Rev.*, **92**, 323–4 (*Oct.* 15, 1953).

Using liquid argon in a specially designed Dewar flask, $Li^7(p, n)$ neutrons, and a hydrogen recoil counter, the authors have measured σ_t(A) at 2 keV intervals in the range 450 to 1100 keV of neutron energy. The experiment was performed in good geometry using the transmission method.

A.

539.172.4

1729. Angular distributions from (n, p) nuclear reactions. N. Austern, S. T. Butler and H. McManus. *Phys. Rev.*, **92**, 350–4 (*Oct.* 15, 1953).

It is shown that angular distributions of high-energy proton groups from (n, p) reactions should evidence sharp maxima near the forward direction, which arise from neutrons with large impact parameters interacting with protons out in the "tails" of the initial nucleus. The positions of these peaks are characterized by the allowed values of orbital angular momenta l_n with which the neutron can be captured to form the final state. A study of such distributions, therefore, may well lead to information concerning spins and parities of nuclear energy levels, as in the case of stripping reactions. For most nuclei, compound nucleus formation should contribute little to such proton groups. For light nuclei, in order that the sharp maxima stand out above the compound nucleus background, it is probably necessary that the incident neutron energy be not near a resonance of the compound nucleus.

A.

539.172.4

1730. Neutron total cross sections at 20 MeV. R. B. Day and R. L. Henkel. *Phys. Rev.*, **92**, 358–61 (*Oct.* 15, 1953).

With the $T(d, n)He^4$ reaction as a monoenergetic source of neutrons of about 20 MeV, the total cross-sections of 13 elements have been measured by a transmission experiment. These cross-sections vary approximately as $A^{\frac{2}{3}}$ as is to be expected from the continuum theory of nuclear reactions. The cross-section for hydrogen at 19·93 MeV is 0·504 ± 0·01 barn. This result, together with other results at lower energies, seems to require a Yukawa potential in both the singlet and triplet *n-p* states and a singlet effective range that is lower than that obtained from *p-p* scattering data.

A.

539.172.4

1731. Total neutron cross section of phosphorus. K. F. Hansen, R. M. Kiehn and C. Goodman. *Phys. Rev.*, **92**, 652–3 (*Nov.* 1, 1953).

The total cross-section of phosphorus for neutrons has been measured in good geometry by the transmission method with a resolution of 2 keV. The energy range is from 125 keV to 850 keV, the neutrons being produced by the $Li^7(p, n)Be^7$ reaction. Red phosphorus contained in a thin steel cylinder was used as scatterer. The neutrons were detected by a hydrogen recoil counter. The neutron beam was monitored by a BF_3 long counter. The average cross-section is 3 barns with an average level spacing of about 25 keV.

A.

539.172.4

1732. The inelastic scattering of fast neutrons in carbon and lead. B. G. Whitmore. *Phys. Rev.*, **92**, 654–5 (*Nov.* 1, 1953).

The inelastic scattering of 14 MeV neutrons in carbon and lead has been investigated by the photographic emulsion method. In carbon, evidence of the excitation of the first excited level is found, as well as excitation corresponding to Weisskopf's evaporation theory. Comparison with previous results for lead gives no evidence for double inelastic scattering in a thick scatterer.

A.

539.172.4 : 539.185

The inelastic scattering of neutrons. *See Abstr.* 1769

539.172.4

1733. Slow neutron resonances in holmium, thulium and lutetium. H. L. Foote, Jr, H. H. Landon and V. L. Sailor. *Phys. Rev.*, **92**, 656–9 (*Nov.* 1, 1953).

The total cross-sections of holmium, thulium and lutetium have been measured over the neutron energy range from 0·1 to ~30 eV. Resonances were found in Ho^{165} at 3·96, 12·8, 19, 22 and 39 eV; in Tm^{169} at

3·92, 14·8 and 17·6 eV. Of the many resonances found in lutetium, the following tentative isotopic assignments have been made: Lu^{175}—resonances at 5·30, 11·4, 14·4, 20·6, 24 and 31 eV; Lu^{176}—resonances at 0·142, 1·57, 2·62 and 4·80. It is probable that many additional resonances are present at higher energies in Lu^{176} but were not observed. The average spacing between resonances in Ho^{165}, Tm^{169} and Lu^{175} (odd-even isotopes) is estimated to be of the same order of magnitude; i.e. respectively 10, 10 and 6 eV; while the spacing in Lu^{176} (odd-odd) appears to be much smaller, of the order of 1 to 2 eV. Parameters for several of the resonances have been obtained. A.

539.172.4

1734. Thermal neutron absorption cross sections of boron and gold. R. S. Carter, H. Palevsky, V. W. Myers and D. J. Hughes. *Phys. Rev.*, **92**, 716–21 (*Nov.* 1, 1952).

The cross-sections of boron and gold, which are widely used as standards for slow neutron measurements, have been determined as functions of wavelength. Total cross-sections were measured in the wavelength range 1·5–10 Å with the Brookhaven slow chopper, the long wavelengths being used to minimize the effects of scattering. The absorption cross-section of boron of "normal" isotopic constitution is 749 ± 4 barns at 2200 m/sec (1·80 Å); the variation of cross-section with boron source is expected to be only about 1%. The measurement of the gold cross-section is complicated by the deviation from $1/v$ resulting from a nearby resonance and by grain orientation effects in the scattering. The 2200 m/sec value, resulting from measurements at long wavelength together with a small correction for the 4·9 eV resonance, is 98·7 ± 0·6 barns. A.

539.172.4

1735. Neutron total cross-section for bismuth and uranium between 45 and 160 MeV. W. I. Linlor and B. Ragent. Letter in *Phys. Rev.*, **92**, 835 (*Nov.* 1, 1953).

The cross-sections, measured by the time of flight method, have minima at about 60 MeV.

J. M. CASSELS

539.172.4

1736. Elastic scattering of fast neutrons by He^4. J. D. Seagrave. *Phys. Rev.*, **92**, 1222–8 (*Dec.* 1, 1953).

Angular distributions of neutrons scattered by helium have been measured at five neutron energies between 2·6 and 14 MeV. A large proportional counter filled with helium and krypton was employed, and the distribution in energy of α-particles recoiling from collimated neutrons observed. All five distributions are similar, and are characterized by strong scattering of the neutrons in the forward direction, a minimum for neutrons scattered near 120° in the centre-of-mass system, and a smaller peak for back-scattering. The location of the minimum moves forward and the ratio of differential cross-sections $\sigma_{back}/\sigma_{min}$ increases smoothly with increasing neutron energy over the range studied. The observed angular distributions are in good agreement with the distributions predicted from analysis of p-He^4 scattering, and support the large splitting of the P states of He^5, and very broad width of the $P_{\frac{1}{2}}$ state. A summary of n-He^4 phase shifts and recent total cross-sec measurements is given.

539.1

1737. Neutron and spontaneous fission in ura ores. W. H. Fleming and H. G. Thode. *Rev.*, **92**, 378–82 (*Oct.* 15, 1953).

The fission yields of the stable isotopes of xe and krypton in natural fission have been determ for six samples of pitchblende and one sampl uraninite. The fission yields observed varied mark from sample to sample. The nature of these v tions and particularly the changes that occur in "fine structure" of the mass yield curves at Xe^{132} Xe^{134} indicate that both spontaneous fission of and neutron fission of U^{235} occur in uranium mine the proportion of each depending on the ura concentration, geological age and the impuritie the mineral. This conclusion is consistent estimates of the neutron flux in these ores base the abundance of Pu^{239} in pitchblende.

539.1

1738. Gas recombination system for a homogen reactor. L. D. P. King, R. P. Hammond, J. Leary, M. E. Bunker and W. R. Wykoff. *N onics*, **11**, 25–9 (*Sept.*, 1953).

Considerable dissociation of the water mode in the Supo homogeneous reactor, at Los Ala results from the energy released by the fission ments. It is found advantageous to recombine hydrogen and oxygen continuously during opera and to return the water to the reactor. The d and performance of the system used for this pur is described. The gases are recombined in cat chambers containing platinized alumina pellets. system has worked satisfactorily for two years d a total energy release of 80 000 kWh. L. R. SHEP

539.

1739. Fission-product potential of commercial tors and their processes. D. Duffey. *Nucleonic* 9–13 (*Oct.*, 1953).

The potential requirements for fission produc large-scale use as sources for sterilization of stuffs, are examined. It is shown that meg fission-product power output would be needed. possibilities for meeting the requirements, in f power reactor programmes, are reviewed.

L. R. SHE

539

1740. Problems in operating a research re R. W. Powell. *Nucleonics*, **11**, 26–31 (*Oct.*, 19

The technical problems involved in operat thermal reactor for research purposes are disc with particular reference to the Brookhaven pil

L. R. SHE

ATOM AND MOLECULE BEAMS . ME NEUTRONS 539.18

1741. A summary of K-meson data. L. Lep Ringuet and B. Rossi. *Phys. Rev.*, **92**, (*Nov.* 1, 1953).

The results of experiments on K-mesons per at the Ecole Polytechnique of Paris and

Massachusetts Institute of Technology are summarized and analysed. A.

539.18

1742. A hypothesis concerning the relations among the "new unstable particles." M. GOLDHABER. *Phys. Rev.*, **92**, 1279–81 (*Dec.* 1, 1953).

An attempt is made to systematize the present knowledge of phenomena concerned with the production, absorption and decay of the "new unstable particles" in terms of only one "new" particle and its "compounds" with nucleons and π-mesons. A.

539.18 : 530.145

The optical model for meson scattering. *See Abstr.* 1060

539.18 : 539.172

1743. Negative μ-meson capture in carbon. T. N. K. GODFREY. Letter in *Phys. Rev.*, **92**, 512 (*Oct.* 15, 1953).

Gives a preliminary account of an investigation of the behaviour of μ-mesons stopped in carbon in the form of an organic liquid scintillation counter. Two types of event are investigated, in the first the pulse from the arriving μ-mesons is followed by a second pulse with a mean delay of 2 μsec indicating that the meson has decayed. In the second the μ-meson pulse is followed by a pulse with a mean delay of 39 milliseconds indicating that a C^{12} nucleus has captured the meson forming B^{12} which subsequently decays by β emission back to C^{12}. Preliminary results indicate that ~10% of the capture reactions result in the formation of B^{12} with resulting β decay. H. ELLIOT

539.18

1744. The attenuation cross sections of 37-MeV pions in hydrogen. C. E. ANGELL AND J. P. PERRY. Letter in *Phys. Rev.*, **92**, 835 (*Nov.* 1, 1953).

A correction for π-μ decay changes the values reported in Abstr. 6235 (1953) to $\sigma(\pi^+) = 11{\cdot}8 \pm 1{\cdot}0$ and $\sigma(\pi^-) = 12{\cdot}9 \pm 1{\cdot}7$ mb. W. J. SWIATECKI

539.18

1745. Observations on the lifetime of the neutral π-meson. B. M. ANAND. *Proc. Roy. Soc. A*, **220**, 183–202 (*Nov.* 10, 1953).

The mean lifetime of the neutral π-meson has been determined by measurements on the "direct" electron pairs associated with nuclear disintegrations and due to an alternative mode of decay, viz. $\pi^0 \rightarrow h\nu + \beta^+ + \beta^-$. The most probable value is 5×10^{-15} sec. The ratio of the probability of this alternative mode of decay to that in which the meson transforms into two photons is $0{\cdot}013 \pm 0{\cdot}004$. A.

539.18

1746. Estimation of mean lifetimes from multiplate cloud chamber tracks. M. S. BARTLETT. Letter in *Phil. Mag.*, **44**, 1407–8 (*Dec.*, 1953).

The equations previously derived [Abstr. 4385 (1953)] for estimating the mean lifetime of unstable particles are extended to deal with observations made in multi-plate chambers. H. ELLIOT

539.18

1747. Analysis of *V*-events. J. PODOLANSKI AND R. ARMENTEROS. *Phil. Mag.*, **45**, 13–30 (*Jan.*, 1954).

From the observed momenta and angles of decays in flight, variables are constructed which are better suited for the analysis than the measured quantities themselves. These variables are $1/P$, the reciprocal of the primary momentum, α, a combination of the longitudinal momenta of the secondaries and either p_t, the transverse momentum, or the quantity $\varepsilon = 2p_t/P$. The regularities in the distribution of the new variables, to be expected from a two-body decay, are discussed. The decay scheme may be derived by comparison with the experimental distributions. A.

539.18

1748. The mean lifetime of the V_1^0-particles. D. I. PAGE AND J. A. NEWTH. *Phil. Mag.*, **45**, 38–46 (*Jan.*, 1954).

This was determined from measurements on 26 selected *V*-decays observed in a large cloud chamber. The chief criterion for selection was that the momentum of the positive secondary particle should be at least three times as great as that of the negative particle. It is shown that this selects events which are predominantly V_1^0-decays. The decay scheme of the particles is assumed to be $V_1^0 \rightarrow P^+ + \pi^- + \sim 37$ MeV. The result of the analysis gives a value of $(3{\cdot}7\ ^{+3{\cdot}9}_{-1{\cdot}3}) \times 10^{-10}$ sec for the mean lifetime. Combining this with other published values, it is concluded that the lifetime is probably between 3·0 and $4{\cdot}5 \times 10^{-10}$ sec. A.

539.18

1749. Search for *V* particles produced by 430-MeV protons. A. H. ROSENFELD AND S. B. TREIMAN. *Phys. Rev.*, **92**, 727–9 (*Nov.* 1, 1953).

Polyethylene was bombarded with 430-MeV protons from the Chicago synchrocyclotron and a search carried out in nearby nuclear emulsions for V_1^0 particles, as well as for possible charged analogues which decay by the process $V_1^+ \rightarrow n + \pi^+ + Q$. No events of either type were found. The upper limits of the cross-sections are respectively 0·35 mb and 0·15 mb per carbon nucleus for the V_1^0 and V_1^+. A.

539.18

1750. Properties of heavy unstable particles. D. LAL, Y. PAL AND B. PETERS. *Phys. Rev.*, **92**, 438–40 (*Oct.* 15, 1953).

A block of emulsion consisting of unbacked emulsion sheets can be used as a very efficient detector for heavy unstable particles and provide favourable conditions for mass and energy determinations. The mass of the τ meson was obtained as $m_\tau = 3m_\pi + Q$, where $Q = 76{\cdot}0 \pm 0{\cdot}9$ MeV. Fairly accurate mass values are obtained for the positive *K* meson and four examples of the capture of negative heavy mesons are presented, two of them leading to emission of a π meson. A charged particle of mass higher than that of a proton which decays in flight into a meson is discussed. In most of these cases the nuclear event giving rise to the heavy mesons could be observed. The *Q* value of the V_1^0 particle was determined as 37 ± 2 MeV and other examples which may represent the decay of neutral particles are discussed. A.

539.18

1751. Charged particles of mass intermediate between proton and deuteron. D. T. KING, N. SEEMAN AND M. M. SHAPIRO. Letter in *Phys. Rev.*, **92**, 838 (*Nov.* 1, 1953).

Two such particles have been observed in nuclear emulsions, one coming to rest and emitting a light

(probably π) meson. Mass estimates of 2560 ± 500 and 2860 ± 850 electron masses are given.

J. J. WILKINS

539.18

1752. Pions from production of baryons by protons. F. J. BELINFANTE. *Phys. Rev.*, **92**, 145–52 (*Oct.* 1, 1953).

When matter is bombarded by very high energy nucleons, over 600 MeV in the laboratory system, part of the pions produced may be decay products of excited nucleons of ordinary spin and isobaric spin $\frac{3}{2}$ ("baryons") produced by the incident nucleons. Assuming charge independence, the authors discuss the ratios of the cross-sections for various possible processes creating one or more pions. A.

539.18

1753. The dependence of the 33-MeV π^+ production cross section on atomic number. R. SAGANE AND W. DUDZIAK. Letter in *Phys. Rev.*, **92**, 212 (*Oct.* 1, 1953).

A spiral orbit spectrometer was used to focus π^+'s (produced by 340 MeV p on Be, C, Al, Cu, Ag, Pb) on a 15·2 in. orbit where they were intercepted by emulsions. Except for Pb which is low, the relative cross-sections follow a $Z^{\frac{2}{3}}$ law. W. J. SWIATECKI

539.18

1754. Pion production and charge independence. A. GAMBA. Letter in *Nuovo Cimento*, **9**, 1032–4 (*Oct.*, 1952).

Assuming charge independence the cross-sections for 1, 2 or 3 π-meson production in 2-nucleon collisions are expressed as simple linear combinations of 3, 6 or 9 constants respectively. [See also Abstr. 6064 (1952).] W. J. SWIATECKI

539.18

1755. Multiple production of pions in nucleon-nucleon collisions at cosmotron energies. E. FERMI. *Phys. Rev.*, **92**, 452–3 (*Oct.* 15, 1953).

The statistical theory of multiple pion production is applied in some detail to the discussion of nucleon-nucleon collisions for primary energies of 1·75 BeV and 2·2 BeV. Probabilities are given for single and multiple productions of pions and nucleons with different charges. A.

539.18

1756. Meson production by 500-MeV negative pions. M. BLAU, M. CAULTON AND J. E. SMITH. Letter in *Phys. Rev.*, **92**, 516 (*Oct.* 15, 1953).

In 460 meson interactions initiated by 500 MeV negative pions from the Brookhaven cosmotron, six events in which two mesons leave the nucleus have been identified. Eight other possible double-departure events have been observed, making the percentage of such events 1·3 to 3% of the total 460 events. In 38% of the interactions, charged mesons leave the nucleus (55% if neutral mesons are considered).

G. E. BROWN

539.18

1757. Characteristics of neutral meson production in the proton bombardment of carbon nuclei. W. E. CRANDALL AND B. J. MOYER. *Phys. Rev.*, **92**, 749–58 (*Nov.* 1, 1953).

The photon spectra radiated from carbon targets bombarded by 340 MeV protons have been measured for various angles of view of the target. Assuming a unique origin of the photons from the decay of a neutral meson into two photons, the energy and rough angular distributions of neutral mesons are deduced from these spectra. The excitation function for producing neutral mesons is also inferred from the measured spectra for various energies of incident protons. The cross-section for the production of neutral mesons per carbon nucleus for 340 MeV protons is $(3{\cdot}4 \pm 0{\cdot}8) \times 10^{-27}$ cm^2. A.

539.18 : 539.172.3

1758. Photoproduction of π-meson pairs. R. D. LAWSON. *Phys. Rev.*, **92**, 1272–9 (*Dec.* 1, 1953).

A perturbation study of the photoproduction of π-meson pairs by γ-rays incident on protons is made for both pseudoscalar and pseudovector coupling. Expressions are derived for the possible cross-sections assuming the nucleon is infinitely heavy. The effect of first-order nucleon recoil on the (π^+, π^-) cross-section, assuming pseudoscalar coupling, is considered. Curves illustrating the results are given. The possibility of obtaining information on the type of interaction operative between mesons and nucleons from a study of the pair production cross-sections is discussed. A.

539.18

1759. π-D scattering and strong coupling theory. H. MIYAZAWA AND S. MATSUYAMA. Letter in *Progr. theor. Phys.*, **8**, 573–4 (*Nov.*, 1952).

Calculations in strong coupling theory are found to be in agreement with the experimental result that the cross-section for π-D scattering is smaller than the sum of those for π^+-H and π^--H scattering [Abstr. 3889 (1952)]. G. FIELD

539.18

1760. On the π-p scattering. K. ONO. Letter in *Progr. theor. Phys.*, **8**, 676–7 (*Dec.*, 1952).

An explanation for the ratio of cross-sections $\sigma(\pi^+) : \sigma(\pi^-) = 9 : 1$ is offered by assuming interference between states of isotopic spin 3/2 and 1/2.

G. FIELD

539.18

1761. Elastic scattering of 118-MeV negative pions by hydrogen. J. OREAR. *Phys. Rev.*, **92**, 156–60 (*Oct.* 1, 1953).

Standard Ilford G5 plates were exposed in the 122 MeV external negative pion beam of the Chicago cyclotron. Scatterings of the pions by the hydrogen in the emulsion were observed by scanning for recoil protons and examining the proton beginnings for an incoming and a scattered pion. Energy-momentum conservation permits separation of similar looking non-hydrogen events from the pion-proton scatterings. Both 400- and 600-micron plates exposed to about 10^6 mesons/cm^2 were area scanned under 830× magnification. A scanning efficiency test composed of the events most difficult to see gave a lower limit of 90% for scanning efficiency. An average pion energy of (118 ± 2) MeV was determined from 23 events where the recoil proton stops in the emulsion. A total cross-section for nonexchange scattering of (9·6 ± 2·0) millibarns has been obtained based on 59 events. The

differential cross-section obtained can be fitted with the formula

$d\sigma/d\omega = (0{\cdot}49 \pm 0{\cdot}15) + (0{\cdot}16 \pm 0{\cdot}21)\cos\chi + (0{\cdot}85 \pm 0{\cdot}45)\cos^2\chi$ millibarns per steradian.

χ is the scattering angle in the centre-of-mass system. This is consistent in shape and magnitude with the results of the Chicago scintillation counter experiments. A.

539.18

1762. Scattering of negative pions by hydrogen. E. Fermi, M. Glicksman, R. Martin and D. Nagle. *Phys. Rev.*, **92**, 161–3 (*Oct.* 1, 1953).

The scattering of negative pions by liquid hydrogen has been studied with the 450 MeV synchrocyclotron, using the pion beams of energy 169 MeV, 194 MeV and 210 MeV. Angular distributions for ordinary scattering and for photon production are presented for each of the three primary energies. The differential cross-sections for ordinary scattering and for charge exchange scattering are computed for the centre-of-mass system. The charge exchange cross-sections when plotted as a function of the energy appear to go through a maximum at about 180 MeV. On the other hand, the ordinary scattering cross-sections appear to increase steadily with the energy. The charge exchange cross-sections, which at lower energies are predominantly backward, become rapidly forward as the energy increases, and are strongly forward at the highest energy. A.

539.18 : 535.33 : 537.531

Studies of X-rays from mu-mesonic atoms. *See Abstr.* 1358

539.18 : 537.534.75

Degradation and range straggling of high-energy radiations. *See Abstr.* 1404

539.185

1763. On the natural decay of the free neutron. S. Tanaka and M. Itô. *Progr. theor. Phys.*, **9**, 169–80 (*Feb.*, 1953).

The decay is investigated where the β-transition of the nucleon is considered to be caused by the intermediation of a boson field. The results are compared with those of Fermi's theory, and the problem of whether the β-coupling belongs to the interaction of the first kind or not is discussed. A.

539.185 : 538.221

1764. Polarisation of thermal neutrons by "non-crystalline" ferromagnets. D. D. Jovanović. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3**, 43–6 (*Aug.*, 1953).

Iron finely dispersed in paraffin wax was obtained by thermal decomposition of ferrous oxalate in melted wax. Thermal neutron transmission measurements, with and without an external magnetic field, showed that iron in this state is more easily saturated magnetically than ordinary microcrystalline iron. J. M. CASSELS

539.185

1765. Note on the equipment for the production of neutrons with a 1·5 MeV accelerator. B. C. Maglić. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3**, 111–18 (*Aug.*, 1953).

Lithium, heavy ice and other targets have been constructed, and their neutron yields have been compared with that of a Ra–Be source. A heavy-water electrolysis apparatus is described. J. M. CASSELS

539.185

1766. The scattering of slow neutrons by liquids. I. Experiments with CH_3OH and CH_3I. J. A. Janik. *Bull. Acad. Polon. Sci. Cl.* **3**, **1**, *No.* 1–2, 45–8 (1953).

The slow-neutron scattering cross-section of molecules in the liquid phase includes an inelastic contribution, corresponding to collisions which excite rotational levels. The cross-section can be calculated [Sachs and Teller, *Phys. Rev.*, **60**, 18 (1941)], and measurements show that the cross-section of CH_3I is accurately predicted. The hydroxyl group in CH_3OH may be able to rotate round the C–O axis, or it may be confined to a 120° arc by the field of the three hydrogen atoms. Experimentally it is found that the slow neutron cross-section of CH_3OH is much lower than would be expected if the hydroxyl group were free to rotate. J. M. CASSELS

539.185

1767. Comparison of Born and Heitler expansions in a scattering problem. N. Fukuda, T. Kobayashi, Z. Maki and M. Sato. Letter in *Progr. theor. Phys.*, **8**, 261–2 (*Aug.*, 1953).

Total cross-sections and angular ratios $d\sigma(180°) : d\sigma(90°)$ for high-energy *n-p* scattering by a central Yukawa potential, calculated in second Born approximation, are compared with the correct values of Christian and Hart [Abstr. 4377 (1950)]. When damping effects are taken into account, they are found to be large and to give more reasonable agreement. G. FIELD

539.185

1768. Neutron-proton scattering near 180° at 93 MeV. W. Selove, K. Strauch and F. Titus. *Phys. Rev.*, **92**, 724–6 (*Nov.* 1, 1953).

A measurement has been made with neutrons of 93 MeV effective energy of the angular distribution of *n-p* scattering near 180° in the centre-of-mass system. The results show that the magnitude of the cross-section approaches the 180° point smoothly, without any sudden increase. A.

539.185 : 539.172.4

1769. The inelastic scattering of neutrons. II. M. J. Poole. *Phil. Mag.*, **44**, 1398–402 (*Dec.*, 1953).

For Pt I, see Abstr. 1918 (1953). Measurements of the spectrum of 2·5 MeV neutrons scattered through 97° from Al, Ni, Bi, W and Au are presented, together with the differential cross-section for the processes. A.

539.185

1770. An experimental search for a stable dineutron. B. L. Cohen and T. H. Handley. *Phys. Rev.*, **92**, 101–2 (*Oct.* 1, 1953).

An attempt is made to detect dineutrons (δ) emitted from hypothetical (p, δ) reactions by observing the activity of the end product of (δ, p) reactions. The activity expected, assuming the dineutron to be stable, is calculated from the statistical theory of nuclear reactions and found to be greater than the maximum observed activity by a factor of 10^5. The acceptance of this result as conclusive would indicate that V_0a^2 for the neutron-neutron interaction cannot be more than 10% larger than for the neutron-proton interaction. A.

539.185

1771. The detection of the free neutrino. F. REINES AND C. L. COWAN, JR. Letter in *Phys. Rev.*, **92**, 830 (*Nov.* 1, 1953).

The reaction $\bar{\nu} + p = n + \beta^+$ has probably been observed near a large pile. The scintillation detector responded to positron pulses followed by a delayed γ-ray pulse produced by capture of the moderated neutron. J. M. CASSELS

539.185.08

1772. Neutron dose measurement. B. HESS. *Z. angew. Phys.*, **5**, *No.* 8, 297–302 (1953) *In German.*

The measurement of dosage for fast neutrons is discussed. Two cellophane-walled ionization chambers are described, and the method used to compensate for the presence of γ-radiation is given. Surveys of the neutron dose in the vicinity of the Paris cyclotron are included. J. HUGHES

STRUCTURE OF SOLIDS 539.2

539.211 : 548.7

1773. The theory of fracture. A. KOCHENDÖRFER. Note in *Naturwissenschaften*, **40**, *No.* 16, 432–3 (1953) *In German.*

Brittle fracture cannot be explained by the concentration of vacant lattice sites by plastic gliding and diffusion. By considering the stability of holes and groups of dislocations in a crystal a mechanism is proposed to account for the origin of microscopic cracks which would lead to fracture in the manner described by Griffiths. M. R. HOPKINS

539.211 : 666 : 534.22

1774. Analysis of brittle fractures in glasses by means of ultrasonics. F. KERKHOF. Note in *Naturwissenschaften*, **40**, *No.* 18, 478 (1953) *In German.*

A new method of following the path of the fracture. The initial speed is 1450 m/s but becomes 500 m/s a few mm from the start. R. O. DAVIES

539.214

1775. Segmental mobility of polymers near their glass temperature. F. BUECHE. *J. chem. Phys.*, **21**, 1850–5 (*Oct.*, 1953).

Glass-forming polymers exhibit a rapid rise of activation energy for molecular motion as T is lowered through the glass temperature. This phenomena is explained here in two different but largely equivalent ways. The first method assumes that in order for a polymer segment to move (i.e. rotate or jump) an energy greater than a critical energy E must be localized on it and its neighbours. The second approach stipulates that a segment may not move unless more than a certain critical amount of free volume is associated with it and its neighbours. Both approaches lead to good agreement with experimental data available for polystyrene and polyisobutylene. The critical values of E and the free volume for these polymers are found and shown to be reasonable. Conclusions are drawn concerning factors influencing the glass temperature. A.

539.215.4 : 519.2

1776. An account of statistical methods for the investigation of finely divided materials. Guide to the experimental design of particle size determinations. M. L. SMITH. *New York and Amsterdam: Elsevier Publishing Co.; London: Cleaver-Hume Press* (1953) *xxiii* + 520 *pp.*

Review in *Nature* [*London*] **172**, 1017 (*Dec.* 5, 1953).

539.216 : 535.51

1777. Measurements of orientation in cotton fibres using polarized light. R. MEREDITH. *Brit. J. appl. Phys.*, **4**, 369–73 (*Dec.*, 1953).

The Becke line method of measuring refractive index was used on account of the irregular form of the cotton fibre. The variation in the calculated spiral angle of the fibrils is closely related to the variation in convolution angle and the data suggests that the average spiral angle in the original unconvoluted fibres may be the same for all varieties. A relation between cell length and spiral angle which holds for wood tracheids and bamboo fibres, also applies to cotton fibres if the "cell length" is taken as the average distance between reversals in spiral direction. Strength and initial Young's modulus are shown to be correlated with the degree of orientation calculated from the observed double refraction. A.

539.217

1778. Measurement of the heat of activation for sodium ion diffusion in glass. R. KAMEL. *J. appl. Phys.*, **24**, 1308–11 (*Oct.*, 1953).

Internal friction peaks resulting from sodium ion diffusion in three kinds of soda glasses have been observed in the temperature range 100° to 200°C for transverse and torsional frequencies between 20 to 400 c/s. The heat of activation for sodium ion diffusion was found to range between 17 000–21 000 cal/mole and might probably be slightly dependent on the sodium content. The results obtained were confirmed by electrical resistivity measurements. For quartz glass and for soda glass having Na_2O content less than 4%, the internal friction peak of the type discussed here could not be noticed, thus indicating that below a minimum Na_2O content of about 4%, ionic sodium diffusion does not contribute to the anelastic behaviour. A.

539.219 : 536.66

1779. Evolution of heat during the ageing of NaCl–KCl solid solutions. L. J. HYVÖNEN. *Comment. phys.-math.* [*Helsinki*] **16**, *No.* 15, 52 *pp.* (1952).

A twin differential calorimeter with automatic recording device for the measurement of slight evolutions of heat was constructed. In order to estimate the proper dimensions of the temperature difference measuring thermopile, conditions determining the sensitivity of the apparatus were analysed. The sensitivity was found to be $14{\cdot}90 \pm 0{\cdot}10$ mcal/hr cm and the fluctuations impairing the accuracy $\pm 0{\cdot}10$ cm. Evolution of heat during the ageing of the equimolar NaCl–KCl mixed crystal has been measured. From the influence of heat treatment on the thermal effect and from the time dependence of the effect two superposed ageing processes may be deduced: (1) a relaxation process obeying an exponential law of decay, probably due to a rearrangement of a short range order; (2) a slowly increasing process, probably due to nucleation. Considering, however, the somewhat speculative character of this statement,

its verification by other means is required. From the temperature dependence of the ageing process the energy of activation was estimated to be 1·1 eV. Comparison with activation energies of diffusion in pure components demands a marked existence of lattice vacancies. The applicability of Wasastjerna's theory to the case of NaCl–KCl is also discussed. The equations by which the theory is expressed at present do not seem to be directly applicable. A.

539.24

1780. Spiral morphology of boron particles. E. L. Simons. Letter in *Nature* [*London*] **172,** 724 (*Oct.* 17, 1953).

Photomicrographs of the solid pyrolysis residue of boron from decaborane show that many of the particles have an external spiral morphology. Pyrolysis of anthracene produced a non-crystalline carbon residue with no regular external structure.

S. WEINTROUB

539.26

1781. A proportional-counter technique for measuring X-ray scattering from powders, fibres and liquids. U. W. Arndt, W. A. Coates and D. P. Riley. *Proc. Phys. Soc.* [*London*] **66,** 1009–16 (*Dec.*, 1953).

Counter spectrometers are described for the accurate semi-automatic measurement of diffracted X-ray intensity over a range of scattering angles from 0° to 130°. A proportional counter is used in conjunction with a linear amplifier and a single-channel pulse analyser. The degree of monochromatization attained with a copper target and nickel filter is such that 99% of the measured intensity is due to Cu $K\alpha$ radiation. The various corrections to be applied are discussed. A.

539.27

1782. Field emission electron microscopy of cathodes with face-centred and body-centred lattice structures. H. Birkenschenkel, R. Haefer and P. Mezger. *Acta phys. Austriaca,* **7,** *No.* 4, 402–16 (1953) *In German.*

The field emission electron microscope was employed to investigate the surface of metals of appreciably lower melting point than that of tungsten, the metal previously most investigated. A continuously pumped tube was employed, in contrast to the sealed-off apparatus usually used. A suitable construction for the cathode is given and the experimental procedure is described in detail. Emission images were obtained from Mo, Ta and Ni and were found to depend primarily on the crystallographic form of the cathode. The characteristic differences between the results from face-centred and body-centred lattice structures are discussed and tentatively interpreted. For the case of Ni, the variations in intensity of emission are related directly to the planes and zones exposed at the tip of the cathode. V. E. Cosslett

539.27

1783. Fine structure lines on (111) faces of ZnS. E. Votava, W. Dekeyser, S. Amelinckx and G. Vandermeersscche. Note in *Naturwissenschaften,* **40,** *No.* 18, 479–80 (1953).

A fine-structure, seen on the (111) faces of ZnS by multiple beam interferometry, is studied by electron diffraction, a Pd-shadowed methylmethacrylate-silica replica technique being employed. The appearances observed are explained in terms of mosaic structure and dislocations. J. Thewlis

539.27

1784. Solid bodies appearing in electron microscope specimens. G. Yasuzumi, T. Morioka, A. Tanaka and K. Kobayashi. *Brit. J. appl. Phys.*, **4,** 338–9 (*Nov.*, 1953).

Impurities may be introduced into the electron microscope specimen in a vacuum and hence into the micrograph. Solid bodies appearing in specimens were examined by means of the electron microscope and electron diffraction. It has been determined that the solid body is carbon black which has been produced as a result of the combustion of vaporized oil or grease by electron bombardment or radiation of a burnt tungsten filament in a vacuum. The necessity of minute care when examining specimens and interpreting their images in the biological area is emphasized. A.

ELASTICITY . STRENGTH . RHEOLOGY
539.3/.8

539.32

1785. Measurement of the elasticity of solid argon by ultrasonic methods. J. R. Barker, E. R. Dobbs and G. O. Jones. Letter in *Phil. Mag.*, **44,** 1182–4 (*Oct.*, 1953).

The velocity of longitudinal (3 Mc/s) waves in solid A formed by slow deposition of the vapour on one face of a plated X-cut quartz crystal was 1600 m/sec at 60°K and 1300 m/sec at 78°K. On the assumption that Poisson's ratio is 1/3, the adiabatic compressibility is estimated as $0{\cdot}36\times10^{-10}$ cm²/dyne at 60°K and $0{\cdot}54\times10^{-10}$ cm²/dyne at 78°K. These values lie within the range covered by different theoretical estimates of the isothermal compressibility.

H. J. H. Starks

539.37

1786. The Ferry reduction and the activation energy for viscous flow. I. L. Hopkins. *J. appl. Phys.*, **24,** 1300–4 (*Oct.*, 1953).

The relationship proposed by Ferry and his co-workers [Abstr. 3433 (1950)] for the effects of frequency and temperature on the dynamic properties of certain polymers is shown to lead to a method for calculating the activation energy of viscous flow from relaxation, creep and dynamic test data, the results agreeing with those obtained in steady-state flow. The Ferry reduction explains, and is supported by, observed increases in dynamic modulus and viscosity with increasing temperature. A.

539.373 : 548.7

Dislocations, plastic flow and creep. *See Abstr.* 1859

539.374

1787. Influence of striations on the plastic deformation of single crystals of tin. K. A. Jackson and B. Chalmers. Note in *Canad. J. Phys.*, **31,** 1017–18 (*Sept.*, 1953).

Single crystals of tin were grown with the (001) planes parallel to their top surface and the [110] direction parallel to their direction of growth. Such

crystals contain striations running parallel to their axis. After deformation in tension a banded structure was observed on the top surfaces of the crystals, the bands being regions with orientations differing by rotations about the *C*-axis. The boundaries of the bands coincide with striation boundaries wherever possible, although in many cases several striations were contained within a single band. Deformation bands in regions of striation-free crystal had quite irregular boundaries. The results are discussed in terms of the characteristics of deformation bands and of striations [see Abstr. 7273 (1953)]. A. D. LE CLAIRE

539.374

1788. The plastic flow of iron and plain carbon steels above the A_3-point. P. FELTHAM. *Proc. Phys. Soc.* [*London*] *B*, **66**, 865–83 (*Oct.*, 1953).

The strain rate $d\varepsilon/dt$ of the steady flow of iron and plain carbon steels containing from 0·05 to 1·15% carbon, subject to constant stress in the temperature range lying between the A_3-points and the solidus T_s, is shown to depend upon the applied stress σ, the absolute temperature T, the latent heat of melting L, and the volume per atom aw, through the relation

$$\frac{d\varepsilon}{dt} = A_0 \exp\left[-\frac{nL}{kT}\left(1-\frac{T}{T_s}\right)\right] \sinh\left(\frac{Nnaw\sigma}{4kT}\right)$$

The form of the equation and micrographic evidence indicate that the dominant rate-controlling mechanism is a recovery process in which disordering of groups of n ($\simeq 20$) atoms is induced at grain boundaries by stress concentrations resulting from the piling up of N ($\simeq 50$) dislocations in slip planes. N and n, but not A_0, are composition dependent. The transient strain ε_{tr} is shown to obey the law

$$\varepsilon_{tr} = t^m B_0 \exp\left[-\frac{H_{tr}}{kT}\left(1-\frac{T}{T_s}\right)\right] \sinh\left(\frac{q_{tr}\sigma}{kT}\right),$$

where m the exponent of the time is approximately equal to $\frac{1}{3}$; B_0 is a composition independent and H_{tr} and q_{tr} are composition dependent constants. A comparison of the last two parameters with corresponding ones in the steady-flow equation suggests that, with certain qualifications, a relation between the steady and the transient flows of the form $\varepsilon_{tr} = \text{const.}\ (td\varepsilon/dt)^{1/3}$, as derived by Mott, may be valid over a wide range of the variables. A.

539.4.013

1789. On the probability distribution for the strength of a specimen and its dependence on dimensions. M. DAVIN. *C.R. Acad. Sci.* [*Paris*] **237**, 869–71 (*Oct.* 19, 1953) *In French.*

It has been shown that the combined strength of elements joined in series is that of the weakest element while that of elements arranged in parallel is the sum of the individual elements. When both methods of combination are used together this idea is shown to be self-contradictory. A resolution is suggested which takes into account the lateral transmission of stresses. R. O. DAVIES

539.417 : 532.13 : 532.61

1790. On the mechanism of the processes of drawing of synthetic textiles. G. BOZZA. *Nuovo Cimento*, **10**, *Suppl. No.* 1, 55–82 (1953) *In Italian.*

The factors affecting the drawing of fibre threads from a more or less viscous mass are analysed. The main processes involved are coagulation, tension and a mechanical force owing to the contraction of the fibre. The first two involve surface tension, viscosity, diffusion, velocity and acceleration in the drawing. These factors are discussed theoretically. J. A. WILCKEN

539.42 : 542.943.5

1791. The "chemical knife"; preservation of ozone for thirty-six days. H. O. ALBRECHT. Letter in *J. chem. Phys.*, **21**, 1421–2 (*Aug.*, 1953).

Stretched rubber breaks off shortly after exposure to a small concentration of ozone. The broken ends were traversed by sharp cracks as though slashed by a knife, but the rubber was not visibly deteriorated. A stretched rubber band was broken almost immediately on exposure to 8% ozone, but an unstretched band was not affected, even superficially, in so short a time. The effect may be due to mechanical activation of the double bonds in the rubber structure at the point of stress, or to rapid penetration of ozone into the surface newly formed by stretching. Ozone can be kept at fairly high concentration for 36 days in a bulb containing potassium permanganate and sulphuric acid, probably because of the removal of oxides of nitrogen and organic matter by the permanganate. A. J. MEE

539.431

1792. Fatigue of metals. R. CAZAUD [Translated by A. J. FENNER]. *London: Chapman and Hall*, *xiv* + 334 *pp.*

Review in *Brit. J. appl. Phys.*, **4**, 318 (*Oct.*, 1953).

539.431

1793. Effects of alternating strain on the structure of a metal. W. A. WOOD AND R. B. DAVIES. *Proc. Roy. Soc. A*, **220**, 255–66 (*Nov.* 10, 1953).

The work is part of researches into the cause of fatigue failure in metals. The effects on the crystalline structure of successive unidirectional tensile strains are compared with the effects of the same strains applied alternately in tension and compression. It is found that X-ray diffraction shows a sharp distinction between the direct and alternating deformation. This is interpreted as showing as a general principle that alternating reversals of a sufficiently small strain do not significantly extend the regions in the grain disturbed by its first application, though they may intensify this local deformation. It is shown that the theory of dislocations could account qualitatively for the localizing of the deformation and the forming of the fatigue crack in the affected regions. A.

539.434

1794. On the validity of Mott's theory of the beta-flow in polycrystals. P. FELTHAM. *Phil. Mag.*, **45**, 9–12 (*Jan.*, 1954).

See Abstr. 7996 (1953). A survey is given of the experimental evidence about the activation energy for transient creep. It is concluded that, if the Andrade equation is written in the form $\varepsilon^3 = At$, the dependence of A on stress and temperature is governed by the same constants as for steady state creep. A.

539.434 : 537.228.2

1795. The electromotive force developed by a creeping zinc crystal. F. D. COFFIN AND S. L. SIMON. Letter in *J. appl. Phys.*, **24,** 1333–4 (*Oct.*, 1953).

A sharp increase in e.m.f. occurs on loading, followed by a slow decay (as the creep strain increases) to a value differing from that exhibited prior to the test. The sudden e.m.f. appears to result from the plastic deformation itself rather than from a change in the nature of the surface. A. J. KENNEDY

539.434 : 551.311.123

1796. Rate of flow of polycrystalline ice. J. W. GLEN. Letter in *Nature* [*London*] **172,** 721–2 (*Oct.* 17, 1953).

Compression creep curves, obtained at $-0{\cdot}02$, $-1{\cdot}5$, $-6{\cdot}7$ and $-12{\cdot}8$°c, showed a transient stage followed by a quasi-viscous stage and for high stresses, but attributed to recrystallization, a tertiary or accelerating stage. The minimum rate of strain $\dot{E}$ varied with stress σ and temperature T as $\dot{E} = B\sigma^{3\cdot3} \exp(-33{\cdot}4 \text{ kcals per mole}/RT)$ but only for the three lower temperatures (B = constant). Measurements at the highest temperature are larger than given by this formula, due probably to local melting. The relevance of these experiments to an understanding of glacier flow is discussed.

A. D. LE CLAIRE

539.501

1797. The sinkage of tracked vehicles on soft ground. I. EVANS. *Brit. J. appl. Phys.*, **4,** 330–4 (*Nov.*, 1953).

The depth of the rut made by a tracked vehicle when crossing soft ground (the "sinkage") is an index of the difficulty experienced by the vehicle. Sinkage is due to plastic flow of the soil under the imposed stresses and can be related to the shear strength of the soil and the characteristics of the vehicle. Two distinct theories are given, one by Micklethwait and Sherratt based on deductive reasoning, and a simpler inductive method by the author. A.

539.531 : 538.221 : 621.317.49

1798. Magnetic measurement of mechanical hardness. D. HADFIELD. *Instn Elect. Engrs Paper* 1576, 7 *pp.* [To be published also in *Proc. Instn Elect. Engrs*].

Describes a new method for the non-destructive measurement of the mechanical hardness of ferromagnetic components, based on the relationship between a "coefficient of magnetic hardness" and the variables in the upper portion of the magnetization curve. It is shown that there is a direct relationship between the magnetic permeability and the mechanical hardness of a low-alloy-content steel, and this is used as the basis of a d.c. magnetic method of hardness measurement for two steel components of diverse character. The construction and performance of portable apparatus for the testing of armour-piercing shot and crank-end bushes is described in detail, and the test results obtained are discussed. The reproducibility of readings is better than 1%; almost linear correlation between instrument reading and mechanical hardness is obtained, and the sensitivity is of a reasonable order. The simplicity of operation is such that unskilled personnel may be employed. A.

539.621

1799. Surface condition and electrical impedance in rubber friction. A. SCHALLAMACH. *Proc. Phys. Soc.* [*London*] *B,* **66,** 817–25 (*Oct.*, 1953).

It is shown experimentally, by employing electrically conductive rubber, that during the frictional gliding of rubber a thin layer in contact with the track undergoes a deformation which considerably increases the electrical impedance of this layer. In the case of previously abraded rubber the layer is permanent. If a d.c. potential is applied between sample and track during sliding, electrostatic attraction between sample and track is produced which increases the frictional force. The thickness of the layer, as estimated from the magnitude of the electrostatic force, is a few thousandths of a centimetre. A.

539.63 : 541.135.5

1800. Electrolytic cold-working and internal friction in palladium/hydrogen alloys. F. A. LEWIS, G. E. ROBERTS AND A. R. UBBELOHDE. *Proc. Roy. Soc. A,* **220,** 279–89 (*Dec.* 8, 1953).

Hydrogen electrolysed into palladium changes the internal friction. In torsional oscillations at 0·54 and 0·22 c/s an immediate large increase of internal friction is observed after charging, or after removing some of the hydrogen by electrolysis. On ageing, the internal friction in such specimens falls to a limiting value, without appreciable loss of hydrogen. This decrease of internal friction obeys approximately a unimolecular rate law, with velocity constant markedly affected by the grain size of the metal. Decay is fastest in annealed specimens with large grain sizes, where in the limit the internal friction returns almost to the value for pure palladium, notwithstanding the presence of about 0·6 H/Pd. In fine-grained charged specimens the internal friction decays to limiting values rather larger than for the pure metal. The observations on palladium/hydrogen suggest that there is a diversity of relaxation processes in the alloy. Electrolysis produces large but temporary "cold-working" which is accompanied by high internal friction. Rested alloys show permanent relaxation effects related to the initial grain size. Brief discussion is given of measured effects of hydrogen on Young's modulus and the rigidity modulus of palladium, both of which are somewhat decreased on charging with hydrogen. A.

539.67 : 548.7

1801. The internal friction of rock salt single crystals. D. R. FRANKL. *Phys. Rev.*, **92,** 573–9 (*Nov.* 1, 1953).

The internal friction of rock salt crystals is markedly decreased by mild X-irradiation. This is interpreted as the pinning of dislocations by cation vacancies liberated from vacancy pairs on the trapping of photo-electrons. Very small applied stresses are capable of breaking the pinning points. Under some conditions, such breakage under the vibrational stress of measurement may lead to a doubly valued dependence of internal friction on strain amplitude. A variety of other phenomena occur, most of them being qualitatively explainable on the basis of damping by moving dislocations. A.

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.124

1802. Equilibria involving the CF(g) and CF_2(g) radicals at high temperatures. J. L. MARGRAVE AND K. WIELAND. *J. chem. Phys.*, **21**, 1552–4 (*Sept.*, 1953).

The absorption spectrum of carbon tetrafluoride (CF_4) gas thermally decomposed under equilibrium conditions in a graphite tube furnace shows the bands of CF_2 at a temperature $T \simeq 1900°K$ and also the bands of CF at a temperature $T \simeq 2400°K$. These results are in approximate agreement with thermodynamic calculations made by Potocki and Mann when the high value of 170 kcal/mole for the heat of sublimation of graphite and when *f*-values of about 10^{-3} for both the CF_2 and the CF bands are assumed. A.

541.124

1803. The reaction of cyclobutane with Hg 6($^3P_1$) atoms. D. L. KANTRO AND H. E. GUNNING. *J. chem. Phys.*, **21**, 1797–1801 (*Oct.*, 1953).

This was studied in a static system at $30{\cdot}10 \pm 0{\cdot}01°C$, over the pressure range from 2–250 mm. The primary products of the reaction are hydrogen, *n*-butylcyclobutane and a saturated C_8H_{14} product which is assumed, from kinetic and mass spectral evidence, to be cyclobutylcyclobutane. In addition, prolonged exposure produced a saturated $C_{12}H_{22}$ product which is probably a dicyclobutylbutane. The quantum yields of pressure decrease (ϕ_P) hydrogen formation (ϕ_{H_2}) and cyclobutane consumption (ϕ_C) all reach constant maximum values at cyclobutane pressures greater than approximately 100 mm. These values are $\phi_C = 0{\cdot}53$, $\phi_{H_2} = 0{\cdot}10$, and $\phi_P = 0{\cdot}16$. From the simple stoichiometry of the reaction the quantum yields of *n*-butylcyclobutane (ϕ_{BC}) and cyclobutylcyclobutane (ϕ_{C_2}) formation were calculated. From the data $\phi_{BC} = 0{\cdot}16$ and $\phi_{C_2} = 0{\cdot}10$. A mechanism for the reaction is proposed. A.

541.126 : 534.222.2

1804. Influence of air pressure on the velocity of ejected explosion gases. C. H. JOHANSSON AND S. LJUNGBERG. *Ark. Fys.*, **6**, *Paper* 35, 369–73 (1953).

The ejection velocity of the explosion gases from the end area of charges in glass tubes was determined at different air pressures from 0·5 mm Hg to 25 atmos. The causes for the great velocities obtained at low pressures have not been clarified in detail, but they are certainly connected with the finite length of the reaction zone. When the detonation front reaches the end surface of the explosive, the intact parts in the reaction zone are accelerated to a high particle velocity, and when detonating, cause an increased front velocity. In Abstr. 5371 (1950) it was established, that the velocity with which the explosion gases escape from detonating charges, is to a high degree dependent on the pressure of the surrounding air. The present investigation gives a quantitative relation between air pressure and velocity. A.

541.127

1805. On rates of approach to equilibrium. S. H. BAUER. *J. chem. Phys.*, **21**, 1888–9 (*Oct.*, 1953).

The limiting conditions on the applicability of an exponential decay law for the rate of approach to equilibrium of a system which is near but not at equilibrium are discussed. Attention is called to a solution which is more general; it consists of a superposition of exponentials, with a spectrum of relaxation times. A.

541.127

1806. Temperature independent factor in the relative rates of isotopic three center reactions. J. BIGELEISEN AND M. WOLFSBERG. *J. chem. Phys.*, **21**, 1972–4 (*Nov.*, 1953).

It is shown that the theoretical equation for the ratio of the rate constants of isotopic molecules is essentially independent of whether the crossing of the barrier is treated as a translation or a vibration. The temperature independent factor in this equation is evaluated for the case of substitution or displacement reactions. Calculations are presented for several cases involving the isotopes of carbon where there is simultaneous bond rupture and bond formation. A.

541.127 : 539.155.2

1807. Intramolecular isotope effects in the reactions of benzoic-α-C^{14} anhydride. V. F. RAAEN AND G. A. ROPP. Letter in *J. chem. Phys.*, **21**, 1902–3 (*Oct.*, 1953).

Theory predicts [Bigeleisen, Abstr. 1288 (1950)] that the ratio of rate constants for a given intramolecular effect should be the same at all temperatures. This has been experimentally confirmed in a study of the reactions of (*a*) ethanol, and (*b*) toluidine with benzoic-α-C^{14} anhydride, having one of the carboxylic carbon atoms labelled as C^{14}. S. J. GREGG

541.127 : 541.14

1808. Kinetics of porphyrin-catalysed chemiluminescent decomposition of peroxides, and the mechanism of photosensitised oxidation. H. LINSCHITZ AND E. W. ABRAHAMSON. Letter in *Nature* [*London*] **172**, 909–10 (*Nov.* 14, 1953).

The kinetics of the chemiluminescent reaction between zinc tetraphenylporphine and tetralin hydroperoxide was studied in tertiary butylbenzene at 149°. The following three-stage mechanism is proposed: (1) $> H.COOH + DH_2 \rightarrow > H.CO. + DH. + H_2O$; (2) $> H.CO. + DH. \rightarrow DH_2^* + > C = O$; (3) $DH_2^* \rightarrow DH_2 + h\nu$ ($> H.COOH$ = tetralin hydroperoxide; DH_2 = dye; DH_2^* = excited dye). S. J. GREGG

ELECTROCHEMISTRY 541.13

541.13

1809. A note on work functions and chemical potentials. P. VAN RYSSELBERGHE. *J. chem. Phys.*, **21**, 1550–1 (*Sept.*, 1953).

It is shown that the work of extraction (equal to the product of work function by molar charge) cannot

be considered as equal to the chemical potential. In particular the electron work function of a metal does not correspond to the chemical potential of the electron in the metal and cannot be used in attempts at obtaining absolute metal-solution potential differences. The exact relationships involving these quantities are derived and linked with Galvani and Volta potential differences. A.

541.133

1810. Anisotropy of the conductivity in flowing polyelectrolyte solutions. V. SCHINDEWOLF. Note in *Naturwissenschaften*, **40**, *No.* 16, 435 (1953) *In German.*

It was observed that the conductivity of solutions of highly condensed phosphates depended on the speed of stirring. In flowing solutions it depended on the flow direction, and with increasing speed of flow it changed gradually to a limiting value. In higher concentrations it depended less on the speed of flow. The change in conductivity was large for solutions of long phosphate chains. It can be explained by the orientation of the chain anions by the flow. Similar observations were made for solutions of soap micelles.

A. J. TAYLOR

541.133

1811. Conductance anisotropy in soap solutions. K. HECKMANN. Note in *Naturwissenschaften*, **40**, *No.* 18, 478 (1953) *In German.*

Micelles formed in soap solutions beyond the so-called critical concentration are, at first, of spherical shape, but grow into cylinders, filaments or lamellae as the concentration increases. This should result in a conductance anisotropy which has indeed been detected qualitatively for solutions of Na cetyl sulphate. [See also preceding abstract and H. Thiele, *Kolloid-Z.*, **125**, 31 (1952)]. F. LACHMAN

541.133.1

1812. Separation of racemic mixtures by electrophoresis in a strong centrifugal or magnetic field. F. C. LENDRUM. *Nature* [*London*] **172**, 499 (*Sept.* 12, 1953).

Suggests, in analogy to a physical model described, a method of separating a racemic mixture—e.g. *d*- and *l*-phenylalanine—in a solution which will cause ionization as an acid, by using a low-voltage electrophoresis current and a strong centrifugal or a non-homogeneous magnetic field applied at right angles to the direction of molecular migration.

F. LACHMAN

541.135

1813. The effect of nitrate-ion and ammonia on the electrolytical separation of hydrogen-deuterium isotopes. J. M. HOJMAN. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3**, 121–6 (*Aug.*, 1953).

It has been found that, while the presence of NO_3^- does not affect the separation factor in the electrolytic process for obtaining D_2O, the electrochemical oxidation of NH_3 causes a small increase in this factor. When H_2 is passed for a long time through the electrolyte, the separation factor decreases again.

F. LACHMAN

541.135

1814. Dissociation, chemical exchange, and the proton magnetic resonance in some aqueous electrolytes. H. S. GUTOWSKY AND A. SAIKA. *J. chem. Phys.*, **21**, 1688–94 (*Oct.*, 1953).

The position of the proton magnetic resonance is concentration dependent in aqueous solutions of electrolytes yielding hydrogen containing ions. Chemical exchange averages the chemical shifts in the proton resonance position over the different chemical species. The averaged shifts observed are correlated with dissociation of the solute, and evidence is obtained in very concentrated solutions for the incomplete dissociation of HNO_3, $HClO_4$ and H_2SO_4 and for the formation of ion pairs of Na^+OH^-. A theoretical analysis of the relation between the magnetic absorption line shape and the chemical exchange frequency suggests that rather short chemical lifetimes can be measured; at least one can infer from the appearance of a single or complex resonance that the average lifetime is greater or less, respectively, than a determinable value in a range about 10^{-2} to 10^{-4} sec. A.

541.135.5 : 621.357.8

1815. The production of fine wires by electrolytic polishing. H. R. HAINES AND B. W. MOTT. *J. sci. Instrum.*, **30**, 459–60 (*Dec.*, 1953).

A simple apparatus is described for reducing the diameter of brittle or easily oxidized metal wires. The technique has been used successfully for thorium, uranium and zirconium, and could be applied to any metal for which a suitable electrolyte is available. A.

PHOTOCHEMISTRY
RADIATION CHEMISTRY 541.14/.15

541.15

1816. X-ray induced polymerization and depolymerization: effects of protecting agents. P. ALEXANDER AND M. FOX. *J. Chim. phys.*, **50**, 415–22 (*June*, 1953) *In French.*

Evidence is given that the X-ray degradation of polymethacrylic acid in aqueous solution in presence of oxygen is due to rupture of C–C bonds by HO_2 radicals. Experiments with a polyphosphate show that the P–O bond is not easily broken by radicals present in irradiated water. There is satisfactory correspondence between the *in vitro* and *in vivo* protection effects of various protecting agents. Some (but not all) protecting agents reduce the yield in X-ray polymerization of methacrylic acid, partly by chain termination and partly by removal of the primary OH radicals. Protection activity and reactivity with OH do not correspond. It is suggested that HO_2 radicals may be important in radiobiological changes. C. B. ALLSOPP

541.15

1817. Radiolysis of dilute solutions of diphenylpicrylhydrazyl (DPPH) in organic solvents. I. Radiolysis of chloroform. A method of chemical dosimetry for ionizing radiations. A. CHAPIRO, J. W. BOAG, M. EBERT AND L. H. GRAY. *J. Chim. phys.*, **50**, 468–81 (*Sept.*, 1953) *In French.*

The radiolysis of chloroform has been followed by observation of the decoloration of dilute solutions of DPPH by γ- and X-rays at 1·2 MeV, 190 kV and

37 kV. The chemical yield appears to be independent of the wavelength. Kinetic studies indicate that at low intensities, the free radicals produced by the irradiation are not uniformly distributed in the irradiated volume. The decoloration of DPPH is a sensitive reaction and may be useful in the dosimetry of ionizing radiations. C. B. ALLSOPP

541.15

1818. Oxidation of indigo carmine in aqueous solution by γ rays. L. MONGINI AND E. L. ZIMMER. *J. Chim. phys.*, **50**, 491–4 (*Sept.*, 1953) *In French.*

Indigo carmine is decolorized by irradiation in aqueous solution in the presence of oxygen (*G* value 14·7), but not in an atmosphere of nitrogen, and the reaction can be followed by direct colorimetry. The *G* value diminishes with radiation dose, but increases as the solutions are made more acid, and varies with the concentration over the range investigated.

C. B. ALLSOPP

541.15

1819. Hot atom recoils from $C^{12}(\gamma, n)C^{11}$. F. S. ROWLAND AND W. F. LIBBY. *J. chem. Phys.*, **21**, 1493–4 (*Sept.*, 1953).

Simple carbon systems have been irradiated with the University of Chicago betatron, producing C^{11} atoms by the reaction $C^{12}(\gamma, n)C^{11}$. The distribution of the radioactive atoms between CO and CO_2 for samples irradiated in the liquid phase was found to be 95–100% CO, and for samples irradiated in the solid phase about 50% of each oxide. A mechanism for these results is proposed. A.

541.15

1820. Hot atom chemistry of the alkyl bromides; absence of effects due to high radiation density; isotope separation in solids. F. S. ROWLAND AND W. F. LIBBY. *J. chem. Phys.*, **21**, 1495–9 (*Sept.*, 1953).

A 30-curie polonium-beryllium neutron source which gives less than 0·1 roentgen per hr in close contact was used to study the hot atom chemistry of a selection of alkyl bromides. Comparison of the results with those obtained with ordinary neutron sources containing γ-rays in abundance up to 700 roentgen/hr equivalent strongly indicates that the essential phenomena reported are free of effects due to the γ-radiation density. The separation of the bromine isotopes in crystalline alkyl bromides has been observed in several additional cases. No isotope effect is shown with CBr_4, however, nor with frozen glasses. The possible theoretical significance of these results is discussed. A.

541.15

1821. The industrial future of radiation chemistry. B. MANOWITZ. *Nucleonics*, **11**, 18–20 (*Oct.*, 1953).

The application of large fission-product γ-irradiators to induce polymerization reactions, is discussed. Experimental data on bulk polymerization of a number of substances are tabulated and extrapolated to give estimated yields in fission-product irradiation. L. R. SHEPHERD

541.15

1822. The action of a flux of neutrons on initiator explosives. H. MURAOUR AND A. ERTAUD. *C.R. Acad. Sci.* [*Paris*] **237**, 700–2 (*Oct.* 5, 1953) *In French.*

Various initiators (e.g. lead azide, mercury fulminate) have been irradiated in the Châtillon pile. No explosions were recorded under varying conditions of flux density and period of radiation.

H. H. GREENWOOD

DISPERSIONS . COLLOIDS . ADSORPTION 541.18

541.183 : 542

1823. Rotary vacuum reaction chambers. J. F. DUNCAN AND D. T. WARREN. *J. sci. Instrum.*, **30**, 462–4 (*Dec.*, 1953).

Two designs of an apparatus which enables a large quantity of powdered solid to be quickly degassed and subsequently exposed to a gas have been developed. In one, the powder is agitated by a rotating paddle; in the other it is contained within a rotating drum. A sample of the powder may be removed from the chamber without losing the vacuum. This apparatus has applications in the study of (*a*) surface adsorption, and (*b*) heterogeneous reactions involving a gaseous and a solid phase. A.

CHEMICAL STRUCTURE 541.2/.6

541.5

1824. Empirical considerations of entropy. I. The entropies of the oxy-anions and related species. J. W. COBBLE. *J. chem. Phys.*, **21**, 1443–6 (*Sept.*, 1953).

The partial molal entropies for oxy-anions and related species have been correlated as a function of the charge, interatomic distance, and certain structural factors. An equation is given by which the entropy for unknown species can now be estimated fairly accurately. In the few cases where the method does not give good agreement, the data are open to suspicion as indicated by other independent observations. Some applications and extensions of the method are indicated for future study. A.

541.5

1825. Empirical considerations of entropy. II. The entropies of inorganic complex ions. J. W. COBBLE. *J. chem. Phys.*, **21**, 1446–50 (*Sept.*, 1953).

A method is proposed by which the partial molal entropies of aqueous complex ions can be correlated in a simple manner as a function of the ratio of their charge to interatomic distance. The agreement obtained between the observed values and those calculated by this method has been shown to be within the accuracy of the experimental data. It is also demonstrated that when the complexing agent is water alone (i.e. no complexing) the proposed equation reduces to an expression similar to that previously obtained by Powell and Latimer [Abstr. 8566 (1951)] for simple monatomic ions. A.

541.5

1826. Empirical considerations of entropy. III. A structural approach to the entropies of aqueous organic solutes and complex ions. J. W. COBBLE. *J. chem. Phys.*, **21**, 1451–6 (*Sept.*, 1953).

A method for estimating the entropy of complex aqueous organic solutes and related species has been developed by a structural extension of a method of Powell and Latimer (see previous abstract) for simple

solutes. The agreement between calculated and observed values is, in general, good, although systematic deviations begin to occur for very complicated and large solutes. The method is extended to the calculation of the entropies of charged organometallic complex ions with good success, and possible applications to systems of biological interest are indicated. Subsequent to the development of the general method for estimating the entropies of aqueous solutes, an empirical equation is also given for calculating gaseous entropies of both inorganic (ionic) and organic molecules from their structures. A.

541.6

1827. The sites of the amino-acid residues on a cyclol model of insulin. G. A. Anslow. Letter in *J. chem. Phys.*, **21**, 2083–4 (*Nov.*, 1953).

To test the proposal of Wrinch (1948) that insulin monomers consist of two 48-unit cyclol cages of molecular weight approximately 6000, models of the sub-units have been built using Fisher–Taylor–Hirschfelder atom units, assigning diazine sites to the more basic residues and linear peptide sites to the more acidic. The resulting model is consistent with the work of Sanger *et al.* (1949, 1951, 1953) on the identification of amino-acid sequences, and gives dimensions for intramolecular distances which have been identified in X-ray diffraction patterns, e.g. the dimer is bounded by a rhombohedral cell approximately $44 \times 50 \times 30$ Å. J. IBALL

541.64 : 538.224

Magnetic study of high polymers. I. Diamagnetic anisotropy of natural rubber. *See Abstr.* 1474

541.65

1828. On the application of the method of coupling of constituents to the bathochromic effect observed in the series of parapolyphenyls. F. Roger. *C.R. Acad. Sci.* [*Paris*] **237**, 385–7 (*Aug.* 5, 1953) *In French.*

The method is applied to the case of like constituents. Good numerical agreement with experimental values is obtained for the wavelength of the first absorption band. The neglect of coupling of non-nearest neighbours, however, does not hold for polyenes. J. JACOBS

541.65

1829. On the application of the method of coupling of constituents to the determination of the first absorption band of alcohol substituted ethylenes. F. Roger. *C.R. Acad. Sci.* [*Paris*] **237**, 483–5 (*Aug.* 31, 1953) *In French.*

The method of coupling of the energy matrices of constituents leads to the law of Carr and Stücklen that the bathochromic shift is proportional to the number of H atoms substituted. A second approximation agrees with the known slight deviation from this law. J. JACOBS

LABORATORY APPARATUS 542.1/.7

542.7 : 621.318.3

1830. Magnetic pumps for corrosive gases and liquids. F. D. Rosen. *Rev. sci. Instrum.*, **24**, 1061–2 (*Nov.*, 1953).

Small, completely sealed, magnetically operated pumps have been constructed for use in circulation of corrosive gases. Successful and extended use has been obtained with gases such as uranium hexafluoride and hydrogen fluoride at pressures up to 175 lb/in.^{2} gauge and 100°C. Pumping characteristics with respect to air at atmospheric suction pressure are given. A.

CHEMICAL PROCESSES 542.9

542.952.7 : 534.39

1831. Depolymerizing effect of ultrasonic cavitation of vapour in a solution in an electric field. P. Renaud and L. Renaud. *C.R. Acad. Sci.* [*Paris*] **237**, 876–7 (*Oct.* 19, 1953) *In French.*

Depolymerization of methyl methacrylate solution in pyridine is found to occur under the influence of ultrasonics only when a high voltage electrical field is applied. T. C. TOYE

CHEMICAL ANALYSIS 543/545

545.37

1832. Polarographic effect of carbon dioxide in solutions of ethyl alcohol. A. A. Vlček. Letter in *Nature* [*London*] **172**, 861–2 (*Nov.* 7, 1953).

A solution of 0·3 M tetramethylammonium chloride in ethyl alcohol (99·8%), after treatment with a current of N_2 containing CO_2 (4 vol. %), and then used in electrolysis with the dropping Hg cathode, gives a well-defined wave (max. at -2 V) on the current-voltage curve, due to the evolution of H from complex particles of solvated CO_2 like $H\overline{C}O_3$, H_2CO_3, and $C_2H_5.HCO_3$. If O_2 be present, the curve has the two O waves as well. The CO_2 wave diminishes with increase of O, due to electrolyte production of $\overline{O}H$ which forms non-reducible $\overline{\overline{C}}O_3$, but can be restored by addition of HCl. H. H. HODGSON

545.83 : 539.172.3

1833. An analysis for deuterium based on the photoneutron effect. C. P. Haigh. Letter in *Nature* [*London*] **172**, 359 (*Aug.* 22, 1953).

Indirect methods of measuring the abundance of D^2 involve chemical preparation and careful purification. This is avoided by using the $D^2(\gamma, n)H^1$ reaction for photon energies $> 2{\cdot}2$ MeV, where the number of neutrons emitted from a sample by a suitable γ-ray source is a measure of the D^2 present. Under constant experimental conditions, a direct comparison with D^2 standards may be made. Na^{24} is used as a γ-ray source. The method, used for measurement of total human body water, will require doses of 20 ml D^2 instead of the 100 ml previously employed. D. V. Mabbs

545.84

1834. Two-dimensional paper chromatography of radioactive substances. F. P. W. Winteringham. Letter in *Nature* [*London*] **172**, 727–8 (*Oct.* 17, 1953).

Describes a technique developed to locate and estimate radioactive substances separated on the conventional form of two-dimensional paper chromatography, using two or more solvent systems to the same labelled mixture. F. LACHMAN

CRYSTALLOGRAPHY 548

548.1

1835. The physical properties of crystals and their symmetry. M. TOURNIER. *Cahiers de Phys., No.* 44, 44–73 (*July*); erratum *No.* 46, 43 (*Nov.*, 1953) *In French.*

An account of the phenomenological description in terms of tensors of the physical properties of crystals. The nature of the tensorial representation is illustrated by several physical properties, and it is shown how the symmetry elements of a crystal determine the number of independent and non-zero components of the tensor. The tensor components necessary to describe the pyroelectric, dielectric, piezoelectric and elastic properties of crystals are given for each of the 32 classes. A. D. LE CLAIRE

548.1

1836. A method for the evaluation of some lattice sums occurring in calculations of physical properties of crystals. B. M. E. VAN DER HOFF AND G. C. BENSON. *Canad. J. Phys.*, **31,** 1087–94 (*Nov.*, 1953).

A method is described for the evaluation of sums of the inverse nth power of the distances from a point P to all points of a lattice. The sums are expressed in sums of Bessel functions or e-powers that converge rather rapidly and Riemann ζ functions. The procedure can be used for any position of P with respect to the lattice. A.

548.1 : 548.5

1837. Interface area, edge length, and number of vertices in crystal aggregates with random nucleation. J. L. MEIJERING. *Philips Res. Rep.*, **8,** 270–90 (*Aug.*, 1953).

The interface area, edge length, and numbers of faces, edges and vertices in an aggregate consisting of a large number of crystals are calculated for two models. In the first ("cell model") the crystals start to grow simultaneously and isotropically from nuclei distributed at random. In the second ("Johnson-Mehl") model the nuclei appear at different moments, the rate of nucleation being constant. Corresponding calculations are made for plane sections of the aggregates and for two-dimensional aggregates. For the one-dimensional case the size-distribution curves are calculated. From a discussion of the results it is concluded that in the two- and three-dimensional cell models the crystals are less equiaxial than in the Johnson-Mehl models. A.

548.3

1838. On the structure of AgI. L. SIEG. Note in *Naturwissenschaften*, **40,** *No.* 16, 439 (1953) *In German.*

AgI treated with iodine vapour (analysis showed about 5×10^{-4} parts "free" I) developed the wurtzite structure. Removal of the excess I *in vacuo* caused reversion to the zinc-blende structure. A. J. C. WILSON

548.5

1839. On the preparation and chemical anisotropy of spherical single crystals of tin. G. BOLOGNESI. *C.R. Acad. Sci.* [*Paris*] **236,** 2414–15 (*June* 22, 1953) *In French.*

548.5

1840. Electron microscopic observations of 111 faces of ZnS crystals. W. DEKEYSER, S. AMELINCKX, E. VOTAVA AND G. VANDERMEERSSCHE. *Phil. Mag.*, **44,** 1142–4 (*Oct.*, 1953).

Palladium-shadowed silica replicas of two (111) faces of a ZnS crystal examined in the electron microscope are reported to show two features of interest. Steps, regular in direction and depth, are interpreted as growth lines while a further series of steps, more irregular and of varying depth, are interpreted as slip lines. A.E.I. RESEARCH LABORATORY

548.5

1841. The growth of platinum crystals out of $PtCl_4$. E. VOTAVA. Note in *Naturwissenschaften,* **40,** *No.* 16, 437–8 (1953).

Platinum crystals grown on a ceramic base show growth spirals with step heights many times the unit cell dimensions, probably due to the effect of impurities. See also Abstr. 7276 (1953). A. R. STOKES

548.5

1842. Production of single crystals of nickel. R. F. PEARSON. *Brit. J. appl. Phys.*, **4,** 342–4 (*Nov.*, 1953).

A detailed account is given and also of the preparation of faces parallel to desired crystal planes. The necessity of melting the material in a vacuum is emphasized and it is shown that this can be done while at the same time the furnace windings are protected by an atmosphere of hydrogen. The particular problem considered is that of shaping the crystal into the form of a "picture frame" and methods of cutting and polishing crystal faces without introducing undue strain are described. A.

548.5

1843. Melting and crystal structure. The mechanism of melting of group I nitrates. W. J. DAVIS, S. E. ROGERS AND A. R. UBBELOHDE. *Proc. Roy. Soc. A,* **220,** 14–24 (*Oct.* 22, 1953).

Melting parameters are reviewed for the nitrates of Li, Na, K, Rb, Cs and Ag, and are compared with values for the corresponding halides. Previously published information has been supplemented by experiments on the viscosity of molten $AgNO_3$, and on the dilatometry and electrical conductivity of $AgNO_3$ in the solid and melt. It is suggested that the low melting-points of group I nitrates, compared with the corresponding halides, is due to the formation of association complexes in the nitrate melts. This process could contribute a term to the overall entropy of fusion S_f without greatly increasing the heat of fusion H_f. Since $T_f = H_f/S_f$, this would explain the unusually low melting-points. The small volume changes of fusion of nitrates, where measured, and the abnormal activation energies for the viscosities of molten nitrates, support the suggested mechanism of melting. A.

548.5

1844. Melting and crystal structure. The onset of "rotation" on melting. A. A. K. AL-MAHDI AND A. R. UBBELOHDE. *Proc. Roy. Soc. A,* **220,** 143–56 (*Nov.* 10, 1953).

Extensive randomization of molecular orientations

or "rotation" is generally thought to occur on melting of certain fairly simple substances. The onset of "rotation" on melting of more complex molecules is reviewed. Special attention has been directed to the behaviour of "stiff" molecules such as benzene derivatives and fused aromatic rings, for which intramolecular crumpling in the melt is likely to be unimportant. The fractional increase in volume $\Delta V_f/V_s$ on melting has been evaluated for a range of compounds from existing density measurements. $\Delta V_f/V_s$ has also been determined experimentally for the molecules 2, 6-dimethyl naphthalene, 2, 3-dimethyl naphthalene, acenaphthene, anthracene, phenanthrene and chrysene. Using bond-distances and Van der Waals repulsion envelopes established by X-ray studies, the increase in volume required to permit "rotation" about different molecular axes in the melt has been calculated. Comparison with the volume increase on melting observed experimentally shows that in many melts containing "stiff molecules" there can be no "rotation" of the molecules. In the present experiments no anomalies occur in such melts even 50° above the melting-point, but it is not yet possible to say whether "rotational" transitions would be observed at higher temperatures in the liquids, similar to the well-known transitions in crystals. On the other hand, "rotation" about at least one of the molecular axes probably does accompany melting for some of the molecules studied, including benzene, bromobenzene, *p*-xylene, acenaphthene, naphthalene and 2, 6- but not 2, 3-dimethyl naphthalene. A.

548.5

1845. The distribution of solute in crystals grown from the melt. I. Theoretical. J. A. Burton, R. C. Prim and W. P. Slichter. *J. chem. Phys*, **21**, 1987–91 (*Nov.*, 1953).

The incorporation of solute elements into single crystals of germanium grown from the melt is examined in terms of a simple model. The theory takes account of the contribution of solute transport in the melt, owing to diffusion and fluid motion, to the over-all process of impurity incorporation during steady-state crystallization. The analysis is extended to treat the transient inclusion of solute which results when the composition of the melt is abruptly changed. A.

548.5

1846. Distribution of solute in crystals grown from the melt. II. Experimental. J. A. Burton, E. D. Kolb, W. P. Slichter and J. D. Struthers. *J. chem. Phys.*, **21**, 1991–6 (*Nov.*, 1953).

Experiments were performed on the distribution coefficients of a number of solute elements in germanium crystals grown from the melt. The variation of distribution coefficient with conditions of crystallization is examined in the light of the theory of Pt I. The incorporation of solute elements into the crystal is shown to depend critically upon the transport processes occurring in the melt. A.

548.5 : 532.787

1847. A study in the mechanics of crystal growth from a supersaturated solution. G. C. Krueger and C. W. Miller. *J. chem. Phys.*, **21**, 2018–23 (*Nov.*, 1953).

An experimental investigation of the concentration field during crystallization is made using an improved modification of W. F. Berg's interference technique. $Na_2S_2O_3.5H_2O$ is crystallized at 23°C; concentrations between 40% and 55%. Graphing the positions of the growing faces *v.* time indicates, in all cases, a uniform rate of growth with occasional abrupt changes. These discontinuities were, in general, correlated with changes in the perfection of the growing face, the disappearance of a region of poor growth being associated with a decrease rate, whereas the appearance of an imperfection led to a higher rate. A minimum of concentration is observed near the face centre, corroborating previous investigations with $NaClO_3$. A diffusion coefficient of $1{\cdot}26\times10^{-5}$ cm²/sec was calculated for $Na_2S_2O_3$ corresponding to $0{\cdot}80\times10^{-5}$ cm²/sec extrapolated from J. D. R. Scheffer's data. There is no strict correlation between maximum, minimum, or average concentration at a crystal face and its rate of growth. It appears that the variations in concentration revealed by interferometer maps are to be interpreted as a consequence of solution depletion occasioned by the crystal's growth. A.

548.5 : 535.37

1848. On growing single crystals of thallium activated alkali halides. J. Franks. *Brit. J. appl. Phys.*, **4**, 377–8 (*Dec.*, 1953).

A description is given of a furnace for producing these according to a modified Stöber method. Some results are given of luminescence measurements on activated alkali iodides, which have an intense emission in the visual range. A.

548.52

1849. A further note upon the growth and optical properties of stearic acid crystals. A. R. Verma and P. M. Reynolds. Letter in *Proc. Phys. Soc.* [*London*] *B*, **66**, 989 (*Nov.*, 1953).

A clarification of some earlier results in the light of a paper by Anderson and Dawson [Abstr. 7282, (1953)]. The latter conclude from electron microscope studies that the spiral growth steps in stearic acid crystals are bimolecular but the present authors have found steps which are odd half-integral multiples of the bimolecular unit. J. IBALL

548.53 : 537.311.31

1850. Precipitation processes in copper–iron alloys. J. Reekie, T. S. Hutchison and F. E. Hetherington. *Proc. Phys. Soc.* [*London*] *B*, **66**, 1101–12 (*Dec.*, 1953).

Measurements of the electrical resistivity of copper-iron alloys, in the annealed condition, have shown that the concept of "coherent" and "incoherent" precipitate can explain the observed features in the resistivity curve. Cold working of the alloys has been shown to result in resistivity changes which are compatible with the idea of "locking-in" of dislocation lines about the precipitated particles of iron. Calculation from X-ray observations of the distance apart of these particles gives a figure of approximately 10^{-5} cm. This is quite close to that estimated from Orowan's equation for the distance between precipitate particles most effective for locking-in of dislocations in an age-hardened alloy. Estimates of the number of vacancies present in a 95% cold worked alloy suggest that

vacancies alone will not account for the observed resistivity increases. At high degrees of cold working, dislocations are probably the predominant factor in increasing resistance. A.

548.58 : 532.73–3

The mechanism of dissolution of salt crystals. *See Abstr.* 1104

MOLECULAR AND X-RAY CRYSTALLOGRAPHY 548.7

548.7

1851. On the dimensions of the ideal crystal lattice. A. G. Smekal. *Acta phys. Austriaca*, **7**, *No.* 3, 324–33 (1953) *In German.*

After brief reference to Born's lattice theory, the article is mainly concerned with a review of the contributions of the author and co-workers to the subject during the past thirty years. S. WEINTROUB

548.7

1852. The evaluation of lattice sums for cubic crystals. J. Hove and J. A. Krumhansl. *Phys. Rev.*, **92**, 569–72 (*Nov.* 1, 1953).

A method is presented of evaluating the sums which arise in calculating the total long-range/interaction energy between a semi-infinite crystal and a particle placed above its surface. For example, if the particle is an ion and the crystal is polarizable, this method facilitates the calculation of the polarization and Van der Waals energies. It is pointed out that many calculations within a solid can be reduced to a combination of cases each of which is of the above type. As an illustration, the total interaction at an interior lattice point is obtained for a simple-cubic structure with an individual atom-pair interaction of λr^{-n}. A.

548.7 : 548.736.4

1853. Physical and crystallographical properties of some spinels. I–II. F. C. Romeijn. *Philips Res. Rep.*, **8**, 304–20 (*Aug.*); 321–42 (*Oct.*, 1953).

From X-ray measurements on simple and complicated spinels regularities in the ionic distribution and lattice constants have been investigated. These regularities have been explained partly by general methods such as the calculation of the Madelung potential and geometrical considerations, partly by taking into account the individual properties of the ions that are correlated with the distribution of electrons within the ion. The calculated correlation between the ionic distribution and the oxygen parameter u was found to be confirmed by the facts. The ultimate choice of the distribution, however, is governed by the individual properties of the ions, partly by their dimensions, partly by the distribution of electrons. Some physical properties of the compounds investigated have been correlated with the ionic distribution. A.

548.7 : 530.145

The crystal momentum as a quantum mechanical operator. *See Abstr.* 1072

548.7 : 536.631

Heat capacity of chain polymeric crystals. *See Abstr.* 1264

548.7 : 536.631

1854. The vibrational spectrum and specific heat of sodium. E. Bauer. *Phys. Rev.*, **92**, 58–67 (*Oct.* 1, 1953).

The frequency spectrum of the normal vibrations of a body-centred cubic crystal lattice is derived by a method suggested by Houston, in which the secular equation is solved along three lines in the reciprocal lattice and the result is interpolated by means of suitably chosen spherical harmonics. Some corrections are applied to the high-frequency part of the spectrum, and the lattice part of the specific heat of metallic sodium is calculated as a function of temperature. A.

548.7

1855. Vibration spectrum of a simple cubic lattice. G. F. Newell. *J. chem. Phys.*, **21**, 1877–83 (*Oct.*, 1953).

Analytic expressions are derived for the frequency distribution function $g(f)$ of a simple cubic monoatomic lattice. Only nearest and next-nearest neighbour interactions are considered, and the latter are assumed to be weak compared with the former. The procedure is based upon considering the next-nearest neighbour interactions as a perturbation, and the results are correct to the first power of a parameter τ which is essentially a measure of strength of the next nearest neighbour forces as compared with the nearest neighbour forces. It has been known for some time that a simple cubic lattice with only nearest neighbour interactions degenerates into the equivalent of three independent one-dimensional lattices giving a non-zero $g(f)$ for $f = 0$ and an infinite value at the maximum frequency. If, however, one includes even a small interaction between next-nearest neighbours, the behaviour of $g(f)$ near both ends of the spectrum changes considerably; in fact it vanishes at both ends. For intermediate frequencies, $g(f)$ is continuous but has four analytic singularities with vertical tangents of the type predicted by van Hove for a quite general type of crystal. Although the calculated $g(f)$ is exact only in the limit $\tau \to 0$, it does properly describe the exact location and type of singularities for $0 \leqslant \tau \leqslant 1/10$. A.

548.7

1856. Lattice dynamics of body-centered and face-centered cubic metallic elements. J. de Launay. *J. chem. Phys.*, **21**, 1975–86 (*Nov.*, 1953).

The body-centred and face-centred cubic monatomic metals are represented by a model consisting of an ion point lattice embedded in an electron gas. The Born–von Kármán lattice dynamics are modified to include the role which the conduction electrons play in acoustical wave motion. This leads to relations connecting the dynamic parameters with the elastic constants, and yields the Fuchs relations in an elementary manner. The discrepancy in the Cauchy relation is shown to be just the bulk modulus of the electron gas. In studying the contribution of the conduction electrons to the thermal motion, two extreme cases are treated: (1) the electron gas does not partake of the thermal motion appreciably; (2) the electron gas follows the ion motion almost exactly. The secular equations are given for both cases. The Debye characteristic temperature in the T^3 region of

atomic heat is computed analytically for both cases when the departure of the elastic constants from the isotropy condition is not too large. A.

548.7

1857. Dynamics of the graphite lattice. H. B. Rosenstock. *J. chem. Phys.*, **21**, 2064–9 (*Nov.*, 1953).

The distribution of frequencies of normal vibrations in the graphite lattice has been obtained in closed form for low temperatures in the two-dimensional approximation for the values $(\alpha, \beta, 0)$ and $(\alpha, \beta, \alpha/2)$ of the force constants (α, β, γ) for nearest, second-nearest, and third-nearest neighbours. The frequencies run from 0 to a finite value ω_{max}, with two logarithmic peaks in their density. The specific heat has been calculated for two special sets of force constant ratios. Deviations from T^2 dependence set in at temperatures much lower than predicted by Debye theory. Comparison with experiment leads to a numerical value for $\theta = \hbar\omega_{max}/k$, from which ω_{max}, and therefore also α and one of the macroscopic elastic constants, c_{44}, may be calculated. θ and ω_{max} appear very sensitive to the assumed force constant ratios, c_{44} less so. A.

548.7 : 539.32 : 539.11

Calculation of the elastic constants of cubic ionic crystals. *See Abstr.* 1513

548.7 : 539.67

The internal friction of rock salt single crystals. *See Abstr.* 1801

548.7 : 530.145

Interaction of a nonrelativistic particle with a scalar field with application to slow electrons in polar crystals. *See Abstr.* 1061

548.7 : 539.11

A variation principle for electronic wave functions in crystals. *See Abstr.* 1512

548.7

1858. Electronic polarizabilities of ions in crystals. J. R. Tessman, A. H. Kahn and W. Shockley. *Phys. Rev.*, **92**, 890–5 (*Nov.* 15, 1953).

A set of electronic polarizabilities has been obtained from a least-squares fit of experimental refraction data using simple additivity and a Lorentz factor of $4\pi/3$. Except for the fluorides, the electronic polarizability values of the alkali–halide crystals calculated from this set agree with the experimental data within 3%. Similar least-squares fits were attempted with various values of the Lorentz factor, the best fit being obtained for $4\pi/3$. On the basis of $4\pi/3$, the additivity assumption and the alkali–halide set, polarizabilities have been obtained for other ions. The best values for the sodium D line in A^3 are Li^+ 0·03, Na^+ 0·41, K^+ 1·33, Rb^+ 1·98, Cs^+ 3·34, F^- 0·64, Cl^- 2·96, Br^- 4·16, I^- 6·43, Ca^{++} 1·1, Sr^{++} 1·6, Ba^{++} 2·5, O^{--} 0·5–3·2, S^{--} 4·8–5·9, Se^{--} 6·0–7·5, Te^{--} 8·3–10·2, Ag^+ 2·4, Cu^+ 1·6, Cu^{++} 0·2, Zn^{++} 0·8, Cd^{++} 1·8, Ge^{4+} 1, Sn^{4+} 3·4, Pb^{++} 4·9. Values represented by a spread indicate ions that cannot be treated additively. A.

548.7 : 539.11

Polarization forces in [ionic] crystals. *See Abstr.* 1511

548.7 : 539.373

1859. Dislocations, plastic flow and creep. N. F. Mott. *Proc. Roy. Soc. A*, **220**, 1–13 (*Oct.* 22, 1953).

Bakerian Lecture, 1953. An outline is given of the experimental evidence that dislocations normally exist in crystalline solids, that they are formed during crystal growth and that they can move when the crystal is stressed. It is shown also from observations of silver halides that networks of dislocations can be formed, and also from observations of crystal growth that piled-up groups of dislocations of high strength can be stable. A discussion is then given of the theory of Frank and Read of the origin of slip lines [Abstr. 673 (1951)]. It is suggested that the elements of the networks serve as sources of dislocations. A difficulty in the theory is to explain coarse slip; it is not understood why one source should produce a large number of dislocations before another comes into play. It is not known at present whether the interaction with sound waves is too great to allow moving dislocations to approach the speed of sound; the explanation of coarse slip may depend on whether this is so. The outlines are given of a theory of ductile fracture; this depends on the production of piled-up groups of several hundred dislocations from each of several active sources; in the neighbourhood of each of these there will be a large concentration of stress. Finally, the concept of "climb" of dislocations is introduced in connexion with recovery and creep, and a tentative explanation of Andrade's law for transient creep is put forward. A.

548.7 : 535.345

Oxygen vacancies in barium oxide. *See Abstr.* 1189

548.7

1860. Annealing of bombardment damage in a diamond-type lattice: theoretical. R. C. Fletcher and W. L. Brown. *Phys. Rev.*, **92**, 585–90 (*Nov.* 1, 1953).

The annealing of isolated interstitial-vacancy pairs presumably introduced by bombardment is considered theoretically with special attention paid to the diamond-type lattice. It is proposed that the annealing can be divided into three stages. First, those vacancy-interstitial pairs having a small initial separation will recombine under the influence of short-range elastic forces. Second, vacancies located initially farther from their companion interstitials will wander according to a random walk process, some of them wandering back within the range of the elastic forces and recombining but some escaping from the vicinity of their interstitials. Finally, vacancies which have escaped in the second stage will continue to wander until captured on surfaces or dislocations or by interstitials other than their own. Approximate analytic expressions are derived for these various stages. An outline is given of a more complete treatment with a quantitative solution for one particular phase of the annealing in the diamond-type lattice. A.

548.7

1861. Annealing of bombardment damage in germanium: experimental. W. L. Brown, R. C. Fletcher and K. A. Wright. *Phys. Rev.*, **92**, 591–6 (*Nov.* 1, 1953).

Experiments have been performed on the annealing of bombardment damage in germanium above

room temperature. The damage was produced by 3 MeV electrons and consisted primarily of isolated vacancy-interstitial pairs. The extent of the damage was determined by measurement of the change in conductivity of *n*-type samples. From the annealing results, the activation energy for the diffusion of vacancies in germanium was found to be about 1·7 eV. The actual annealing curves have been fitted in terms of the model of the annealing process described in the preceding abstract. A.

548.7

1862. Electronic structure of *F* centers: hyperfine interactions in electron spin resonance. A. F. Kip, C. Kittel, R. A. Levy and A. M. Portis. *Phys. Rev.*, **91**, 1066–71 (*Sept.* 1, 1953).

It is shown that the observed width of the microwave electron spin resonance absorption lines associated with *F*-centres in KCl, NaCl, and KBr crystals can be attributed to hyperfine interactions between the *F*-centre electron and the nuclear magnetic moments of the ions adjacent to the *F*-centre. The width arises from the distribution of nuclear moment components. Theoretical calculations of the width are in good agreement with observation provided that the *F*-centre wave function is treated as a linear combination of atomic orbitals; wave functions calculated on continuum models are shown to be unsatisfactory. The theory is confirmed by a comparison of observations on *F*-centres in crystals of $K^{39}Cl$ and $K^{41}Cl$. If the width is attributed to interactions with the nearest sets of K and Cl ions, the experiments lead directly to quantitative values of the electronic charge density at the K and Cl nuclei: one finds $|\Psi(K)|^2 = 0{\cdot}70 \times 10^{24}$ cm^{-3} and $|\Psi(Cl)|^2 = 0{\cdot}12 \times 10^{24}$ cm^{-3}. A.

548.7

1863. Electronic structure of *F* centers: saturation of the electron spin resonance. A. M. Portis. *Phys. Rev.*, **91**, 1071–8 (*Sept.* 1, 1953).

It is shown that the unusual observed saturation behaviour of the microwave electron spin resonance associated with *F*-centres in KCl, NaCl, and KBr crystals can be accounted for if the overall width is ascribed to interaction between the *F*-centre electrons and the nuclear magnetic moments of the ions adjacent to the *F*-centres. The measured saturation factor gives for *F*-centres in KCl a spin-lattice relaxation time of $2{\cdot}5 \times 10^{-5}$ sec at room temperature. The observed saturation behaviour in which only the absorption saturates is in marked disagreement with the Kramers–Kronig relations. However it is shown, that the Kramers–Kronig relations are not applicable to saturated systems. Expressions which avoid the use of these relations are presented for saturable systems. A.

548.7

1864. The production of *F'*, *M*, and *R* centers in NaCl at room temperature. R. T. Platt, Jr and J. J. Markham. *Phys. Rev.*, **92**, 40–4 (*Oct.* 1, 1953).

One may produce a variety of absorption centres to the long wavelength side of the *F* band. The ones most carefully studied are the *F'*, R_1, R_2 and *M* bands. In NaCl at room temperature, the *R* bands overlap and resemble the *F'* band; indeed, it is not possible to tell if the "erregt" state, so extensively studied by the workers in Göttingen, is due to *R* or *F'* centres. An experimental study of these bands has been made. It indicates that the *F*, *F'*, and *M* band form during X-radiation. Since the lifetime of the *F'* band at 300°K is short, it dissociates during the course of the usual absorption measurement. To obtain reliable growth rate of the *F* band during X-radiation the contribution of the *F'* band must be taken into account. The *R* bands are formed primarily by optical bleaching of the *F* band. The experiments indicate that the "erregt" state at room temperature is due to the presence of the *R* bands. A.

548.7

1865. Energy of trapped electrons in ionic solids. K. Lehovec. *Phys. Rev.*, **92**, 253–8 (*Oct.* 15, 1953).

The calculations of Simpson on the energy of an electron localized in a crystal, at an impurity carrying a single positive charge, have been extended to impurities carrying a multiple positive charge. The thermal and optical activation energies corresponding to the transition of the electron from the 1*s*-orbit to the conduction band are derived. The various contributions to the polarization energy of the lattice near the impurity are analysed in detail, which leads to an expression differing from that used by Simpson. The results are applied to a tentative interpretation of activation energies of SiC crystals as observed by Busch. A.

548.7

1866. Bleaching properties of *F* centers in KBr at 5°K. J. J. Markham, R. T. Platt, Jr and I. L. Mador. *Phys. Rev.*, **92**, 597–603 (*Nov.* 1, 1953).

The bleaching properties of *F* centres in KBr have been investigated experimentally at 5°K and 78°K. The stability of *F* centres towards bleaching is dependent on the temperature and mode of formation. Those produced by additive colouration are stable; those produced at room temperature by X-rays bleach slightly; those produced at 78°K by X-radiation show some bleaching; while those produced at 5°K by X-radiation show a large initial instability. Some tentative theoretical conclusions are made. A.

548.7

1867. The colouring of diamonds by neutron and electron bombardment. R. A. Dugdale. *Brit. J. appl. Phys.*, **4**, 334–7 (*Nov.*, 1953).

This and some effects of subsequent heating are described. The colouring is associated with the introduction of Frenkel defects by bombardment. Evidence for the natural occurrence of radiation coloured diamonds is presented. A.

548.7 : 535.345

Optical absorption and photoconduction in the visible and near infrared in single crystals of BaO. *See Abstr.* 1188

548.7 : 538.221

Ferromagnetic domain processes in single crystal disc specimens of silicon iron. *See Abstr.* 1459

548.73/.74 : 539.26/.27

X-ray and electron investigation of materials. *See Abstr.* 1781–4

548.732

1868. Extinction in X-ray diffraction patterns of powders. A. R. LANG. *Proc. Phys. Soc.* [*London*] *B*, **66**, 1003–8 (*Dec.*, 1953).

Errors are pointed out in analyses by Hall and Williamson [Abstr. 2252 (1952)] and by Weiss [Abstr. 7178 (1952)] of extinction in powders. Formulae are proposed giving a first-order correction for the reduction of reflecting power of small spherical crystals due to primary and secondary extinction. Neither formula accounts adequately for differences between observed and calculated intensities in Hall and Williamson's measurements on copper and aluminium. A.

548.733

1869. An X-ray camera with helicoidal movement. F. HUERTA. *An. Real. Soc. Españ. Fis. Quim.*, **48 (A)**, 147–52 (*May–June*, 1952) *In Spanish.*

This is studied and the most important properties of the corresponding diagrams are determined, as well as the methods which have to be employed for their interpretation. Its greater simplicity with respect to the Weissenberg diagrams is outlined. A.

548.734

1870. Data for X-ray analysis: Volume I. Charts for the solution of Bragg's equation (*d* versus θ and 2θ). W. PARRISH AND B. W. IRWIN (108 *pp.*). Volume II. Tables for computing the lattice constant of cubic crystals. W. PARRISH, M. G. EKSTEIN AND B. W. IRWIN (90 *pp.*). *Eindhoven: Philips Gloeilampenfabrieken, N.V.; London: Cleaver-Hume Press.*

Review in *Brit. J. appl. Phys.*, **4**, 351 (*Nov.*, 1953). "These volumes are intended to supplement the *International tables for X-ray crystallography*, Vol. I. of which has already been published for the International Union of Crystallography; and the charts for X-ray crystallography prepared by The Institute of Physics, London."

548.734.4

1871. Systematization of the study of rotary crystal diagrams. F. HUERTA. *An. Real. Soc. Españ. Fis. Quim.*, **48(A)**, 135–46 (*May–June*, 1952) *In Spanish.*

The proposed systematization consists in studying the relationship between the two plane spaces, i.e. the stratum from the lattice and the plane of the diagram (in case the camera should be cylindrical the film is supposed to be developed on a plane), based upon the formulae of transformation between those spaces. General formulae are deduced which determine the rotatory angle of the crystal, the diffraction angle, the relation between them and other interesting magnitudes in function of the parameters which determine the problem. Making use of these formulae it is easy to deduce in each method the transformation formulae, and in order to show the application there is a detailed study with Weissenberg diagrams. A.

548.735

1872. Image theory of superposed vector sets. M. J. BUERGER. *Proc. Nat. Acad. Sci. U.S.A.*, **39**, 669–73 (*July*, 1953).

A discussion, in terms of image theory, of the methods of Clastre and Gay and Garrido [Abstr. 7613 (1950)]. By superposing a vector set with two displaced sets instead of one, the image can be obtained without its inverse. A. R. STOKES

548.735

1873. Solution functions for solving superposed Patterson syntheses. M. J. BUERGER. *Proc. Nat. Acad. Sci. U.S.A.*, **39**, 674–8 (*July*, 1953).

See preceding abstract. In the *product function*, several Patterson functions with displaced origins are multiplied together; the *minimum function* at any point is the smallest of several Patterson functions with displaced origins. The minimum function is better than the product function, which is better than the sum function, for isolating a structure from the background. See Abstr. 9125 (1950). A. R. STOKES

548.735

1874. An intersection function and its relations to the minimum function of X-ray crystallography. M. J. BUERGER. *Proc. Nat. Acad. Sci. U.S.A.*, **39**, 678–80 (*July*, 1953).

See two preceding abstracts. This function equals $A + B - |A - B|$, where A and B are the values of two Patterson functions, one displaced relative to the other. It shows the region of overlap of the functions, and equals twice the minimum function. A. R. STOKES

548.735

1875. Optical methods in the determination of structures by X-rays. M. CUBERO AND V. HERNÁNDEZ MONTIS. *An. Real Soc. Españ. Fis. Quim.*, **48(A)**, 133–4 (*May–June*, 1952) *In Spanish.*

A short survey by optical methods on the structure of rutile (TiO_2) is described. A "fly's eye" has been used in studying the problem of Fourier analysis, and the building up of the image has been carried out by means of the Patterson synthesis. A.

548.736

1876. Electron compounds of transition elements. H. J. BEATTIE, JR. *J. appl. Phys.*, **24**, 1322–4 (*Oct.*, 1953).

The work of many investigators has strongly indicated that sigma phase is characterized by a certain averaged electronic structure. The characteristic was first thought to be the "electron vacancy" concentration in the *d* band, but it is now appreciated that the density of electrons outside the argon shells may also be valid criterion. The latter characteristic is used here with the application of H. Jones' (1934) theory. The result shows a definite correlation between the homogeneity ranges and the X-ray diffraction patterns for sigma phase and several other complicated structures which occur in alloys of transition metals. A.

548.736.3

1877. Structure of vitreous B_2O_3. H. RICHTER, G. BREITLING AND F. HERRE. Note in *Naturwissenschaften*, **40**, *No.* 18, 482–3 (1953) *In German.*

X-ray investigations show a large number of sharp maxima, belonging to a highly ordered arrangement of BO_3-groups in layers, with the shortest distance between layers of 1·85 Å. C. TURNER

548.736.3 : 539.133

The crystals and molecular structure of tetraborane. *See Abstr.* 1541

548.736.4

1878. A new structure type for metallic oxides of formulae A_6BO_8. J. KASPER AND C. L. CHRIST. Letter in *J. chem. Phys.*, **21**, 1897 (*Oct.*, 1953).

Two examples are Mg_6MnO_8 and Cu_6PbO_8. The unit cell is cubic and contains 32 oxygen atoms nearly close-packed; 28 metal ions are fitted in the spaces between them. A. R. STOKES

548.736.4

1879. An X-ray examination of an α(Al–Fe–Si) ternary compound. K. ROBINSON AND P. J. BLACK. *Phil. Mag.*, **44**, 1392–7 (*Dec.*, 1953).

The unit cell of an α-phase in the Al–Fe–Si system is found to be hexagonal with $a_0 = 12{\cdot}3$ Å and $c_0 = 26{\cdot}2$ Å, and differs from the cells previously reported for other phases of closely similar composition. The most prominent Brillouin zone associated with the structure of this compound is compared with that of one of these other phases with special reference to the possible "effective valency" of transitional metal atoms in electron-rich environments. A.

548.736.5 : 535.375.54

Optical properties and crystal structure of $KHCO_3$. *See Abstr.* 1202

548.737

1880. Evidence for globulite molecules in ribonuclease. D. WRINCH. Letter in *J. chem. Phys.*, **21**, 2099–2100 (*Nov.*, 1953).

A consideration of the vector projection maps of Carlisle and Scouloudi [Abstr. 7392 (1951)] leads to the conclusion that there is a high probability of a globulite type of skeleton in this protein molecule. [The figure printed above the legend for figure 1 obviously belongs to some other paper.] J. IBALL

548.74

1881. A neutron diffraction study of potassium dihydrogen phosphate by Fourier synthesis. G. E. BACON AND R. S. PEASE. *Proc. Roy. Soc. A*, **220**, 397–421 (*Dec.* 8, 1953).

Projections of the distribution of atomic nuclei in potassium dihydrogen phosphate at room temperature have been obtained by Fourier synthesis of single-crystal neutron diffraction data. Series termination effects have been examined and corrected for, either by specific assessment of the diffraction rings or by difference syntheses. The parameters so obtained are confirmed by least-squares analyses and give a reliability index of 7%. Hydrogen peaks occur midway between two oxygen atoms and appear circular when viewed along the O—H—O bond, but elliptical when viewed across it. The PO_4 tetrahedra are much more nearly regular than previously supposed, and the O—H—O bonds are inclined at not more than $\frac{1}{2}°$ to the *xy*-plane. A.

548.74 : 537.533.73

The problem of achromatism in electron diffraction. *See Abstr.* 1381

GEOPHYSICS 55

550.38 : 538.24

Self-reversal of thermo-remanent magnetization of igneous rocks. *See Abstr.* 1475

550.384 : 523.74

1882. Geomagnetic activity and the sunspot cycle. R. ANANTHAKRISHNAN. Letter in *Nature* [*London*] **172**, 854–5 (*Nov.* 7, 1953).

For the periods 1945–49, 1935–39, 1926–30 and 1915–19 (sunspot maxima) the international magnetic character figures are used to classify individual days into four groups of varying strengths of activity. It is found that the number of highly-active days in each period is more closely correlated with the mean daily solar prominence profile areas than with the Zürich relative sunspot numbers. M. W. OVENDEN

551.241

1883. On some physical aspects of the theory of the origin of mountain belts and island arcs. A. E. SCHEIDEGGER. *Canad. J. Phys.*, **31**, 1148–55 (*Nov.*, 1953).

It is shown that a physical explanation can be given within the framework of the contraction hypothesis of orogenesis for the four types of junctions of island arcs and mountain belts observed by geologists. A.

551.311.123 : 539.434

Rate of flow of polycrystalline ice. *See Abstr.* 1796

ATMOSPHERE . METEOROLOGY 551.5

551.501

1884. Micrometeorology. O. G. SUTTON. *London: McGraw-Hill* (1953) *xii* + 333 *pp.*

Review in *Proc. Phys. Soc. B*, **66**, 903 (*Oct.*, 1953). "Deals with the physical processes in the lowest layers of the earth's atmosphere, mainly in the first hundred metres . . . applications in the fields of agriculture, biology, hydrology and atmospheric pollution. This is the first complete textbook treatment of the subject."

551.508.15

1885. Continuous determination of atmospheric ozone. J. CARBENAY AND A. VASSY. *Ann. Geophys.*, **9**, *No.* 4, 300–8 (1953) *In French.*

A device for continuous chemical quantitative determination, using an automatic starter and photographic recording. It improves somewhat on previous types, particularly in that a washing of the reaction bowl after each measurement eliminates traces of iodine and used products. A.

551.510.41 : 537.568

Three-body recombination of oxygen in the upper atmosphere. *See Abstr.* 1435

551.510.535

1886. The *h't*-measurement of ionosphere at the time of the annular eclipse of May 9, 1948, at Wakkanai, Hokkaido in Japan. H. Uyeda, H. Kudo, T. Shimizu and R. Sato. *Rep. Ionosphere Res. Japan*, **4**, *No.* 2, 75–7 (1950).

The measurement was carried out at three fixed frequencies: 2·1 Mc/s, 4·5 Mc/s and 7·05 Mc/s in expectation of making clear the continuous time-variation of the ionospheric layers during the eclipse. The result shows that (1) the absorption in and below *E*-layer decreased as the eclipse approached its maximum and increased again as the eclipse left its maximum, (2) the maximum electron density of F_2-layer began to decrease immediately after the first contact of the eclipse, till it attained its minimum at 12^h05^m, which was about 15 min later than the time of maximum eclipse, and seemed to recover toward the end of the eclipse. But the degree of absorption and of eclipse did not correspond regularly, perhaps due to the asymmetrical location of the active coronal area on the solar disk. A.

551.510.535

1887. The recombination coefficient and the temperature variation in the upper atmosphere at night. T. Yonezawa. *Rep. Ionosphere Res. Japan*, **4**, *No.* 2, 79–85 (1950).

The nocturnal electron density variations of the F_2-layer above Kokubunji, near Tokyo was analysed. The values of recombination coefficient show a marked seasonal change, the maximum being in January ($\alpha = 3{\cdot}3\times10^{-10}$ cm^3 sec^{-1}) and the minimum being in July and June ($\alpha = 0{\cdot}3\times10^{-10}$ cm^3 sec^{-1}). The relative temperature changes obtained are reasonable in summer and equinoctial seasons, the ratios of the absolute temperature at dawn to that at sunset being 0·3–0·5, but in winter the ratios are too small to be accepted as true, and in this season some mechanism other than temperature variation must be taken into consideration. A.

551.510.535

1888. Penetration of neutral particles into the upper atmosphere. M. Sumi. *Rep. Ionosphere Res. Japan*, **4**, *No.* 3, 147–53 (1950).

The penetration of neutral particles of high speed into the upper atmosphere is considered under several assumptions. The penetrating height is estimated, using approximate methods, and the possibility of producing an ionized layer is also discussed. A.

551.510.535

1889. A comparison of the electron density variations in the *F*2 region at Kokubunji and Yamagawa during the night. T. Yonezawa. *J. Geomagn. Geoelect.*, **3**, 32–6 (*July*, 1951).

By this comparison it has been made clear that, if a linear law of electron disappearance and somewhat higher temperature of the upper atmosphere at Yamagawa than at Kokubunji are assumed, the observational data fit theoretical expectation rather well, but a quadratic law can hardly be reconciled with the observations, unless recombination coefficient changes markedly with height. A.

551.510.535

1890. The electron density of the *D* region. T. Sato. *J. Geomagn. Geoelect.*, **4**, 44–62 (*July*, 1952).

Studies the electron density, its seasonal and daily variation, and the distribution with height of the *D* region. For this purpose, the seasonal and daily variation of the reflection coefficient of waves of 16 kc/s and 150 kc/s incident in the ionosphere were calculated assuming the distribution of the electron density, and maximum electron density N_0 (though its existence is uncertain) of the *D* region and collisional frequency ν_0 at the height of N_0. To calculate these values, the levels of the reflection of these waves were first discussed. Then N_0, ν_0, and the distribution of the electron density which give a reflection coefficient consistent with the results observed, not only with long waves but also with short waves, were deduced. It was found that: (1) waves were reflected from the level $x = \sin^2\theta[y_L^2 + Z^2]^{1/2}$ and not $x = \sin^2\theta$ or $x = \sin^2\theta\,.Z$; (2) the distribution of the electron density has the form such as $N_0^{\frac{1}{2}(1-z-e^{-z}\sec\chi)}$ or a similar one; (3) the electron density at the height of 90 km and 75 km is $1{\cdot}8\times10^4$ cm^3 and 6×10^2 cm^3 respectively in daytime in the summer and 9×10^3 cm^3 and 3×10^2 cm^3 in daytime in the winter; (4) if the region has a peak it is situated at the height of 92–95 km in daytime; and (5) the collisional frequency at 92 km is 4×10^5/s. A.

551.510.535

1891. On the latitudinal distribution of maximum values of f_0F2 in its diurnal variation. T. Yonezawa and T. Shimazaki. *J. Geomagn. Geoelect.*, **4**, 94–101 (*Dec.*, 1952).

Assuming that the temporal rates of electron production and removal in the *F*2 layer are of the forms $q_0(\cos\chi)^m$ and αN^n, respectively, where χ is the solar zenith distance, N is the electron density and q_0, α, m and n are constants, the latitudinal distribution of maximum values of f_0F2 in its diurnal variation has been considered, with a view to limiting the ranges of possible values for m and n. The results show that both m and n should be contained in a range roughly between 1 and 1·5, which suggests that a process of attachment type must be predominant in diminishing electron density. A.

551.510.535

1892. Electric currents in the ionosphere. I. The conductivity. W. G. Baker and D. F. Martyn. *Phil. Trans A*, **246**, *No.* 913, 281–94 (1953).

An earlier suggestion by Martyn that the effective conductivity of the ionosphere in the dynamo theory is enhanced by polarization of the Hall current is examined in quantitative detail. General expressions are given for the conductivities of a thin ionized sheet oriented at an angle to a uniform magnetic field. The effective conductivity of such a (spherical) sheet surrounding the earth is shown to be greater than either the Pedersen or the Hall conductivities. The variation of conductivity with latitude is calculated for the ionospheric level of maximum effective conductivity. Consideration is given to the height-integrated conductivity of the actual ionosphere, and effective values deduced. It is shown that the F_2 region will move bodily under the influence of the

electric field from lower regions, thereby reducing its ability to shunt the Hall polarization field. The effective conductivity over most of the earth is found to be sufficient to satisfy Stewart's dynamo theory. In a narrow strip at the equator the conductivity is enhanced, thereby accounting for the anomalously large magnetic variations found to occur in these regions. A.

551.510.535

1893. Electric currents in the ionosphere. II. The atmospheric dynamo. W. G. BAKER. *Phil. Trans A*, **246**, *No.* 913, 295–305 (1953).

Assuming semi-diurnal tidal air flow a solution is made of the atmospheric dynamo problem, taking account both of the direct and transverse conductivities of the ionosphere. The spherical sheet ionosphere is divided into three regions, a narrow equatorial zone, and two wide polar caps, taking appropriate constant conductivities in each region. The current system is similar in shape and phase to that derived on the assumption of uniform (direct) isotropic conductivity, but is considerably more intense than that which would be obtained without the existence of transverse (Hall) conductivity. The electric field system is very different, however, from that derived on this (isotropic) assumption. An abnormally large east-west current is found at the equator, which appears to provide the explanation of the anomalous magnetic variation in this region. Curves are given showing the distribution of the field and current components. A.

551.510.535

1894. Electric currents in the ionosphere. III. Ionization drift due to winds and electric fields. D. F. MARTYN. *Phil. Trans A*, **246**, *No.* 913, 306–20 (1953).

An analysis is made of the drift velocity of the (neutral) ionization in a uniform ionosphere under the influences of an electric field and/or atmospheric wind. It is shown that this drift of ionization produces the Ampere body force on the medium; the electric current flows perpendicular to the drift. The motion of a cylinder of ionization, of density differing from the surrounding medium, is then studied. It is found that the motion is electrodynamically stable, but unstable hydrodynamically, if Hall conductivity is appreciable. In the latter event there is rapid accretion of (neutral) ionization on one side of the cylinder, depletion on the other. It is suggested that this is the origin of sporadic $E(E_s)$ ionization, and is likely to be an important factor in the production of the long-enduring meteor trails detected by radio methods. Formulae are derived for the horizontal and vertical drift of ionization at all latitudes in a thin ionosphere in which vertical electric currents are prohibited by polarization. Graphs are given which permit derivation of the true wind or field in a given region of the ionosphere from experimental observations of the drift velocities. A.

551.510.535

1895. Note on the grazing-incidence integral $\mathrm{Ch}(x, \chi)$ for monochromatic absorption in an exponential atmosphere. S. CHAPMAN. Note in *Proc. Phys. Soc.* [*London*] *B*, **66**, 710–12 (*Aug.*, 1953).

An appendix to the Chapman theory of ionospheric layer production indicating simplified methods by which the function $\mathrm{Ch}(x, \chi)$ for grazing incidence may be calculated. G. M. BROWN

551.510.535

1896. Direction-finding studies of large-scale ionospheric irregularities. E. N. BRAMLEY. *Proc. Roy. Soc. A*, **220**, 39–61 (*Oct.* 22, 1953).

Describes the results of directional measurements on pulse signals reflected from the ionosphere, on various frequencies in the range 2 to 15 Mc/s. The measurements have been made at vertical and oblique incidence (distance 700 km), and the observed directional variations have been interpreted in terms of ionospheric tilts. At any instant the direction of the tilt may be regarded as random; the magnitude is found to be similar, on the average, in each of two orthogonal directions. The way in which the tilts change with time and distance have been studied, the latter by means of observations using either spaced receivers or transmitters. The tilts at a given point in region *F* are found to be uncorrelated at a time interval of about 5 min during the day and about 10 min during the night. At a given time they are uncorrelated at points separated horizontally by about 50 km. There is appreciable negative correlation at greater time intervals at a single point, and there may be a similar effect in the space-correlation. Observations are described which indicate large-scale horizontal movements in the ionosphere. In the sporadic *E*-layer these appear to be in the nature of drifting clouds of ionization, while in the *F*-layer the effects are such as would be produced by horizontally travelling ripples in the surfaces of constant ionization density. These ripples have wavelengths of 50 to 400 km and speeds up to 350 m/s. The direction of motion tends to be more often towards the east or west than towards the north or south, and evidence of a diurnal change has been obtained. A.

551.510.535

1897. Recombination and diffusion and spread echoes from the ionosphere. T. L. ECKERSLEY. *Proc. Phys. Soc.* [*London*] *B*, **66**, 1025–38 (*Dec.*, 1953).

This is concerned with the explanation of the spread *F*-echoes often obtained on frequency-sweep records of equivalent height in the ionosphere, especially at night and in the auroral regions. It is shown in an appendix that the production of a mountain range of echoes from a single incident pulse can be accounted for if there is a periodic structure of ionization in the *F*-layer. There are two mechanisms of ionization in the ionosphere, namely, the incidence of ultraviolet radiation from the sun, and the influx of a stream of charged particles that are deflected by the earth's magnetic field towards the geomagnetic poles. The ultraviolet light produces well defined layers, the E, F_1 and F_2-layers, with a single maximum of ionic density within them, and they may be satisfactorily explained by Chapman's theory, taking into account the recombination process but neglecting diffusion effects. In the case of particle ionization, however, the effect of diffusion becomes predominant. It is shown in the paper that the inclusion of the diffusion term in the differential equation of layer formation leads to the possibility of a periodic structure within the *F*-layer of the kind needed to explain the spread

echoes. This is because the differential equation has as its solution a doubly periodic elliptic function that provides the required periodicity of ionic density as a function of height. The form of the mathematics gives the essentially periodic nature of the solution without any detailed appeal to the initial conditions, but reference is made to the auroral curtains indicating the existence of sources of charged particles that maintain the periodic structure of ionization in between the curtains. Whereas the ultraviolet light causes layers to be formed that are many wavelengths thick, the particle ionization causes very thin layers only two or three wavelengths thick embedded in the background of ionization. A.

551.510.535 : 538.566.3

Radio-wave propagation in the ionosphere. *See Abstr.* 1499–1503

551.510.535 : 550.381

1898. On the effect of the earth's magnetic field on the virtual height of the ionosphere. T. Sato. *J. Geomagn. Geoelect.*, **3**, 90–9 (*Dec.*, 1951).

The virtual height is calculated of the reflection point of a radiowave incident in the ionosphere at a frequency of $0{\cdot}834\,f_c$, where f_c is the critical frequency of the ionosphere, in the presence of the earth's magnetic field. The magnitude of the retardation of the wave resulting from the transmission in the lower ionized layer is also calculated. The inclination of the magnetic field vector is taken as 0°, 30° and 90°. It is found that the virtual height of the reflection point of the wave at a frequency of $0{\cdot}834\,f_c$, which is equal to the actual height of the ionosphere in the case of no magnetic field, does not indicate the actual height in the presence of the earth's magnetic field, and the value of the retardation depends on y, which is the ratio of the gyro-frequency to the wave frequency, and on f_1/f_2, where f_1 and f_2 are the critical frequency of the lower and upper ionized layers respectively. Further, it is also found that the effect of the earth's magnetic field on both virtual height and retardation is maximum, when the inclination of the earth's magnetic field vector is 0°, that is, on the magnetic equator; and minimum when the inclination is 90°, that is, on the magnetic pole. A.

551.510.535 : 550.384

1899. The solar-flare type variation in geomagnetic field and the integrated electrical conductivity of the ionosphere. T. Nagata. *Rep. Ionosphere Res. Japan*, **4**, *No.* 3, 155–72 (1950).

Under the assumption that solar-flare type variation in geomagnetic field is caused by an anomalous increase in the electrical conductivity of the ionosphere, the mode of this variation is dynamo-theoretically dealt with as a transient phenomenon. The magnitude of the change in electric current in the ionosphere and the time from its beginning to its maximum range, when compared with the observed changes, provide for the limit of the amount of the conductivity. This argument yields the value for the integrated conductivity of the ionosphere of order of magnitude 5×10^{-8} e.m.u. This is in a good agreement with the value deduced from ionospheric observations. A.

551.510.535 : 550.384

1900. The solar-flare type variation in geomagnetic field and the integrated electrical conductivity of the ionosphere. II. Effect of *F*-layer. T. Nagata and T. Suzuki. *Rep. Ionosphere Res. Japan*, **4**, *No.* 4, 201–5 (1950).

Transient changes in geomagnetic field caused by the dynamo-action of a conductive layer under the effect of mutual inductance of other concentric layers are examined. The result shows that the multi-layers of the ionosphere can be replaced by a single layer, the integrated conductivity of which is equal to the conductivity integrated vertically throughout the whole conductive region. This conclusion confirms that the integrated electrical conductivity of the whole ionosphere is around 5×10^{-8} e.m.u. or less. A.

551.510.535 : 550.384

1901. On the influence of the Hall current to the electrical conductivity of the ionosphere. I. M. Hirono. *J. Geomagn. Geoelect.*, **2**, 1–8 (*May*, 1950).

It is suggested that the effect of the electric field produced by the vertical component of the Hall current, together with the smaller effect due to its horizontal component, may construct, along the magnetic equator in the ionosphere, a narrow region, in which the conductivity near the level of the E layer is much greater than in the other latitudes. This result is considered to be in accordance with the latitude distribution of the range of diurnal variation of terrestrial magnetism. A.

551.510.535 : 550.384

1902. On the influence of the Hall current to the electrical conductivity of the ionosphere. II. M. Hirono. *J. Geomagn. Geoelect.*, **2**, 113–20 (*Dec.*, 1950).

It is shown that there is a narrow region along line of zero dip near the E layer, of about 15° of latitude wide in which conductivity is very great, as a result of polarization by the Hall current. The effect of this belt is discussed by the dynamo theory, giving the result that this belt will cause enhanced diurnal variation of magnetic field near the geomagnetic equator. A.

551.510.535 : 550.384

1903. A theory of diurnal magnetic variations in equatorial regions and conductivity of the ionosphere *E* region. M. Hirono. *J. Geomagn. Geoelect.*, **4**, 7–21 (*April*, 1952).

The theory reported in the two preceding abstracts is discussed further in detail. A dynamo theory for the E region with anisotropic conductivity, which is linked by highly conductive lines of magnetic force to the F region, is examined. A case that the E layer only makes a tidal oscillation, which produces observed lunar diurnal current system, is calculated. It is found that, in middle latitudes, the induced polarization field in E-W direction due to the Hall current is greater than that due to the direct current, and the vertical drift of the $F2$ layer due to this polarization field seems to be adequate for the observed $F2$ lunar variation. According to the present theory, conductivity of the E region at the magnetic equator decreases with increase of the main magnetic field, and the distribution of range of magnetic variations along the magnetic equator, reported by Egedal, seems to support this relation. A.

551.510.535 : 550.384

1904. Circulatory motions in the ionospheric atmosphere and their relation to the *S* field of the terrestrial magnetism. I. S. MATSUSHITA. *J. Geomagn. Geoelect.*, **1**, *No.* 2, 35–40 (*Oct.*, 1949).

Southward, and less frequently northward, shifting of ionic clouds of E_s ionization have been tracked at five observatories in Japan with a mean apparent velocity ~370 km/hr. Relations between the direction of the shifting and the type (*P*, *E*, etc.) of the daily variation of *H* are obtained, suggesting that circulatory motions in the ionosphere are the cause of the S_q and S_D variations. G. M. BROWN

551.510.535 : 550.384

1905. Circulatory motions in the ionospheric atmosphere and their relation to the *S* field of the terrestrial magnetism. II. S. MATSUSHITA. *J. Geomagn. Geoelect.*, **1**, *No.* 2, 41–7 (*Oct.*, 1949).

Evidence for circulatory motions in the atmosphere is provided from studies of the meridional distribution of the virtual height of the ionosphere, and of the phase and amplitude of the diurnal variation of the virtual height of the *F*2 layer. Calculations on the dynamo theory suggest that the lower layer of the circulatory motions may produce the S_q and the upper layer the S_D terrestrial magnetic variations. The shifting of the ionic clouds in E_s (preceding abstract) must be assumed to flow by the air current of the upper layer of the circulatory motions.

G. M. BROWN

551.510.535 : 550.384

1906. Circulatory motions in the ionospheric atmosphere and their relation to the *S* field of the terrestrial magnetism. III. S. MATSUSHITA. *J. Geomagn. Geoelect.*, **2**, 9–19 (*May*, 1950).

The relations between the shifting of ionic clouds of the *F*2-layer and the sporadic-*E* and the type of the daily variation of terrestrial magnetism are discussed, and also the relation of the semi-diurnal variation of the ionosphere to the *S* field of terrestrial magnetism. Research on the dynamo effect due to both the diurnal and the semi-diurnal variation is being conducted. A.

551.510.535 : 550.384

1907. Electro-dynamical behaviour of the ionosphere region viewed from geomagnetic variations. T. NAGATA, N. FUKUSHIMA AND M. SUGIURA. *J. Geomagn. Geoelect.*, **2**, 35–44 (*Aug.*, 1950).

Dynamo-theoretical calculations of the longitudinal inequality of S_q-field, the solar flare type variation, S_D-field and magnetic bays show a fairly good agreement with respective observed facts, not only in their mean states but also in their dynamic behaviours. Thus, it is concluded that the dynamo-action of the ionosphere can be responsible for various geomagnetic variations such as mentioned above as well as S_q and *L*. Taking into account the screening effect of the ionosphere and the transient characteristics of electric current in the ionosphere, the integrated conductivity of the ionosphere is presumed to be $5\times10^{-8} \sim 10^{-7}$ e.m.u., in place of 3×10^{-6} hitherto assumed, and the velocity of its lateral motion is estimated to be of order of magnitude 10^2 m/sec. Finally, some remarks on the dynamical characters of magnetic and ionospheric storms are mentioned from the above view point. A.

551.510.535 : 550.384

1908. On the electrical conductivity of the upper atmosphere. K. MAEDA. *J. Geomagn. Geoelect.*, **2**, 45–53 (*Aug.*, 1950).

Deals with the problem of the electrical conductivity supported by the upper atmospheric ionization, to which the diurnal variation of terrestrial magnetism is attributed in the dynamo theory. Number densities of free electrons and ions and their collision frequencies are substantially important for the evaluation of the vertical distribution and integrated value of the electrical conductivity. For this purpose various elementary processes governing the ionospheric characteristics, that is, recombination, attachment, detachment and collision, are discussed on the basis of ionospheric observation with the aid of some theoretical data due to other scientists. It is indicated that the total conductivity will be about 2×10^{-7} e.m.u. during the daytime, with a maximum conductivity of $(1{\cdot}5 \sim 2{\cdot}0)\times10^{-14}$ e.m.u. in the *E*-region. A.

551.510.535 : 550.384

1909. The effects of atmospheric motion and dynamo current on the electron density of the ionosphere. K. MAEDA. *J. Geomagn. Geoelect.*, **3**, 77–89 (*Dec.*, 1951).

Deals with the possibility that the ionospheric electron density is affected by the flow of the charged particles (electrons and neg. and pos. ions) associated with the atmospheric mass motion and dynamo current from the dynamo-theoretical aspect. The theoretical relationships among the electron density, atmospheric motion and dynamo current are deduced and some numerical examples as applied to the *F*2-layer are given. The effect of dynamo current is small in comparison with that of atmospheric mass motion, which must account for the dynamo current corresponding to the *Sq* field of geomagnetic variation. A.

551.510.535 : 550.384

1910. Dynamo-theoretical conductivity and current in the ionosphere. K. MAEDA. *J. Geomagn. Geoelect.*, **4**, 63–82 (*July*, 1952)

Tensor expressions of anisotropic velocity and conductivity of a simple ionized gas in magnetic field are applied to the ionosphere as a heterogeneous ionized medium. It is shown that the vertical electric current in the ionosphere is suppressed down to a negligible magnitude, and on this assumption the specific conductivities of the ionosphere are derived. With these conductivities the dynamo-theoretical equation is constructed and solved for some special models of the ionosphere. The directional conductivities of the ionosphere are introduced and explained. The vertical motion of electrons and ions in the ionosphere is considered and its importance is briefly noted from the viewpoint of the ionospheric distribution. A.

551.510.535 : 550.384

1911. Distortional characteristics of the world-wide distribution and diurnal variation of the ionospheric F_2 layer associated with the geomagnetic variation. K. MAEDA. *J. Geomagn. Geoelect.*, **4**, 83–93 (*Dec.*, 1952).

As the continuation of the previous report (preceding abstract), the effect of vertical motion of

electrons on the electron density of the F_2 layer is analytically treated. The vertical velocity of electrons in the F_2 layer is connected to the density of the horizontal dynamo current, which is obtained by solving the dynamo-theoretical equation, conserving the non-coincidence of the geographical and geomagnetic axes. The cyclic equation giving the electron density, wherein the term representing the effect of vertical motion is included, is solved with some approximations. Comparison of the calculated results with the observed data shows that the electron density depression and the height rise around noon near the magnetic equator, the longitudinal inequality of the latitude distribution of the noon density and the shape of daytime variation of electron density for the F_2 layer are plausibly interpreted by the present theory. A.

551.510.535 : 551.594.5

1912. On the auroral zone current. T. NAGATA. *Rep. Ionosphere Res. Japan*, **4**, *No.* 2, 87–101 (1950).

Eleven examples of the distribution of hourly mean values of the auroral zone disturbance in the geomagnetic field in the Second International Polar Year are analysed, being separated into parts of external and internal origin. The external part is about 2·6 times the internal one. The distribution of the overhead current corresponding to the external part of the auroral zone disturbance is calculated on assumed various heights, the result showing that, judging from the convergency of the form of current distribution, the height of the current may probably be 100 km or less; that is, it is situated in *E*- or *D*-layer. Southward shifting of the auroral zone current during the development of a magnetic storm was re-ascertained, and it was found that the width of the auroral zone current is about $4° \sim 7°$ in angle of latitude. The maximum intensity of the current responsible for moderate magnetic polar disturbances is $400 \sim 800$ A/km. This conclusion indicates that the electron number in *E*- or *D*-layers in the auroral zone at the time of magnetic disturbance becomes more than that in calm periods by a few multiples of 10, resulting in a markedly large attenuation of radiowaves passing through the auroral zone. A.

551.510.535 : 621.396.11

1913. Scattering of short wave radio signals and their bearing on the ionosphere. S. S. BANERJEE, D. K. BANERJEE AND V. D. RAJAN. *J. sci. industr. Res.*, **12A**, 278–82 (*June*, 1953).

After a review of previous work on the scattering of pulse signals, some results obtained by the authors at Banaras are considered. Observations at oblique incidence indicate that scattering can be observed on any occasion when reflected signals are absent independent of the presence of any *E*- or E_s-layer provided that sufficient power and sensitivity are available. This suggests that the scattering takes place at the ground. Scattering at vertical incidence has been observed with low-power transmissions, even in the presence of the split magneto-ionic components.

G. M. BROWN (R)

551.510.535 : 621.396.11

1914. Scattering of radio waves and horizontal gradient of ionization in the ionosphere. S. S. BANERJEE AND D. K. BANERJEE. Letter in *J. sci. industr. Res.*, **12B**, 277–9 (*June*, 1953).

Vertical incidence scattering observed on low power (preceding abstract) is explained in terms of a sharp horizontal gradient of ionization ($\sim 10^5$ electrons/cm^3 per 100 km) and also an undulation in the ionosphere over the transmitter. G. M. BROWN

551.593.11

1915. On the theory of superior mirage. O. HAUG. *Meteorol. Ann.*, **3**, *No.* 12, 15 *pp.* (1953).

Previous theories of the formation of the superior mirage do not account for the occasional appearance of more than two images. Calculation of the actual ray path through an inversion with linear variation of index with height shows the possibility of four images. More than four images probably arise from double reflections within the inversion layer.

R. W. FISH

551.593.5

1916. Contribution to the study of the scattering of light by the particles in suspension in the lower atmosphere at Paris. H. GRISOLLET. *Cahiers de Phys.*, *No.* 43, 21–53 (*May*, 1953) *In French.*

A detailed account of experiments performed in the grounds of the observatory at Montsouris during the years 1934–38. The scattered light intensity was compared with the light diffused by a white screen using a polarization photometer incorporating a Wollaston prism, and observations were made for 5 different angles and the degree of polarization perpendicular to the light beam was also measured. The particulate matter present was studied with an Owen's jet dust counter. The recorded values were compared with the theory of Mie and Rocard, but were not in exact agreement. It was shown that there were two principal sizes of particle, namely, about 0·13 and 2–3 μ, present in the Paris atmosphere. J. M. HOUGH

551.593.9

1917. Photoelectric studies of the night sky light. II. M. HURUHATA. *Rep. Ionosphere Res. Japan*, **4**, *No.* 3, 137–46 (1950).

For Pt I, see *Rep. Ionosphere Res. Japan*, **1**, *No.* 1 (1947). The intensities of infrared radiation were measured in various directions, and intensity distribution in the whole sky and its variation in one night were examined. The horizontal shifting of the bright night sky light wave could be recognized in many nights, mostly from north to south with a speed of about 1000 km/hr, which is a little larger than the movements of some ionospheric data previously found. The shifting affects the heights of the night sky light layers reduced from the intensities in different altitudes. A.

551.593.9

1918. Description of an automatic photometer for the study of the night sky light. A. BAILLET, D. BARBIER, F. BOSSON, A. LALLEMAND AND J. MAGUERY. *Ann. Géophys.*, **9**, *No.* 4, 309–16 (1953) *In French.*

The photometer in a 7-minute cycle, measures the intensity of the light, separated by an appropriate filter, first along a small circle of constant zenithal distance and then at the zenith itself. The mechanical parts and electric circuits are described. The receiver is a Lallemand photomultiplier. A.

551.593.9

1919. Some results on the spectrum of the light of the night sky. D. BARBIER. *C.R. Acad. Sci.* [*Paris*] **237,** 599–601 (*Sept.* 21, 1953) *In French.*

In the photographic region (3000 Å to 5000 Å) recent spectrograms giving higher resolution permit of more accurate band identifications. The Herzberg bands of O_2 are confirmed; but previous identification of the Vegard–Kaplan components at 4166 Å and 4416 Å has had to be abandoned since the new profiles are quite unlike those observed in auroral spectra. In the visual region (5000 Å to 6500 Å) a spectrogram obtained in June, 1951, shows a hitherto unrecognized emission feature at 6160 Å of intensity comparable with that at 6363 Å. This is tentatively ascribed to the Na doublet, 6451–61 Å, although the companion, 5683–88 Å, if present, is surprisingly weak. No other spectrograms to date have shown this feature with certainty. D. R. BARBER

551.593.9 : 535.338.3

1920. A new determination of the altitude of the atmospheric layer emitting the green line of oxygen in the light of the night sky. J. DUFAY, P. BERTHIER AND B. MORIGNAT. *C.R. Acad. Sci.* [*Paris*] **237,** 828–30 (*Oct.* 12, 1953) *In French.*

A determination by photographic spectrophotometry during the winter of 1952–1953, of the intensity ratio of the forbidden [O I] line at 5577 Å at zenith distances, 11·5° and 78·5°, gives a value of 250 km for the mean height of emission. This agrees well with recent photoelectric measures. D. R. BARBER

551.594.13 : 551.594.221

1921. Sudden changes in the atmospheric electric phenomena accompanying lightning discharges. I. M. KAWANO. *J. Geomagn. Geoelect.*, **2,** 100–12 (*Dec.*, 1950).

Changes in the atmospheric electric conductivity and in the space charge accompanying lightning discharge were examined during summer in 1948–50. It was found that the conductivity increases remarkably at the time of lightning discharge. This increase in the conductivity may be attributable to an anomalous ionization by some mechanism accompanying lightning discharges. A.

551.594.221 : 537.523.4

The pilot streamer in lightning and the long spark. *See Abstr.* 1352

551.594.25 : 621.315.1.017.14

1922. Capture of uncharged particles by an electrified obstacle. R. COCHET. *J. Rech. Cent. Nat. Rech. Sci.*, **4,** 153–80 (*June*, 1952) *In French.*

See Abstr. 4457 B (1951) *J. Rech. Cent. Nat. Rech. Sci.*, **3,** (No. 15) 337–42 (1951) and Abstr. 7756 (1952). Further studies of losses in high voltage d.c. lines through fog. The general equation for the behaviour of a particle in the neighbourhood of a charged obstacle is derived. Graphical methods are then employed to trace the trajectories of fog droplets in the vicinity of charged cylinders. From these curves the coefficients of capture of droplets are deduced for the obstacles. The form of the trajectories in the neighbourhood of a h.v. conductor has been verified experimentally for stationary air conditions. The minimum quantity of water required to form drops on a smooth conductor capable of emitting ions has been determined and an estimate of the current loss can be made. The evolution of an electrified water drop in a cloud above 0°C is also studied and it is shown that small charged drops can grow rapidly while falling a short distance. A. E. KAY (R)

551.594.6

1923. Experimental study on scattered echoes. I–II. T. KŌNO. *Rep. Ionosphere Res. Japan*, **4,** *No.* 3, 127–35; *No.* 4, 189–99 (1950).

The experimental determination of the source of the scattered echoes was first carried out. It was found that they were caused by multiple reflection between the ionosphere and the earth, and it is considered that the scattering reflection was caused by earth. It was then shown that the field intensity of the scattered echo was calculated by experimental formula. Also, it was shown that the scattering phenomenon exerted an influence on the specific route of radio communication. A.

BIOLOGY 57/59

577.9

1924. The idea of autoreproduction, the basis of heredity. P. L'HÉRITIER. *Cahiers de Phys., No.* 43, 7–20(*May*, 1953) *In French.*

The paper, given at a conference on "Physics and Biology," outlines the facts and the theories connected with the way in which chromosomes, and especially genes, reproduce themselves. It seems that specific long range forces are necessary to explain the mechanism. The importance of nucleic acids in heredity is emphasized and the author points out that recent researches have led to the recognition of the important part which the cytoplasm probably plays in the transmission of specific characteristics from generation to generation. J. IBALL

578.088 : 534.39

1925. Pressure thresholds for biologically active cavitation. E. ACKERMAN. *J. appl. Phys.*, **24,** 1371–3 (*Nov.*, 1953)

Experiments are described which measure the threshold acoustic pressures necessary for cavitation which can destroy certain biological cells. These thresholds are in the neighbourhood of 0·3 atmos. in the frequency range from 0·4 to 500 kc/s. At lower frequencies much greater pressures appear necessary and the type of biological damage is different. An interpretation of these results is discussed. A.

578.088.5

1926. Effects of commercial and radiation-produced hydrogen peroxide. T. ALPER. Letter in *Nature* [*London*] **172,** 957–8 (*Nov.* 21, 1953).

The problem of determining the extent to which H_2O_2 is an agent in the biological action of radiations is confused by "stabilizer" in commercial H_2O_2.

Radiation-produced H_2O_2 should be used in such experiments. F. T. FARMER

578.088.5 : 534.39 : 538.566

1927. Heating of fat-muscle layers by electromagnetic and ultrasonic diathermy. H. P. SCHWAN, E. L. CARSTENSEN AND K. LI. *Commun. and Electronics*, *No.* 8, 483–8 (*Sept.*, 1953).

The rates of generation of heat in a 3 cm layer of fat and in underlying muscle for the two types of radiation are calculated over a wide frequency range. Measurements of propagation constants for fat in the range 100–1000 Mc/s in the e.m. case, and 0·5–10 Mc/s in the ultrasonic case are given, and it is shown that effective heating of muscle beneath fat can be achieved with frequencies greater than 500 Mc/s for e.m. radiation and greater than 1 Mc/s for ultrasonic. F. T. FARMER

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612 : 537.542

Scintillation counting and its medical applications. *See Abstr.* 1416

612.84

1928. Photometric illusions. C. JAUSSERAN. *J. Phys. Radium*, **14**, 36 S–38 S (*Oct.*, 1953) *In French.*

Methods are described for producing an illusion in which concentric annuli of radially increasing intensity (discontinuities in which apparently produce the annuli) are seen as dark rings on a lighter background. The illusion is produced also in intermittent illumination. The effect is ascribed to a synthesis of the general radial intensity gradient and the local gradient variations in each annulus. When the screen was obstructed so as to reveal but one annulus the darkening of the edges disappeared. Photometric measurements showed that when a small test-patch was moved within the pattern the luminance recorded corresponded to the objective intensity. But when the test-patch was removed from the pattern to its immediate neighbourhood the brightness variation was revealed. R. A. WEALE

612.843

1929. Saturation of the rod mechanism of the retina at high levels of stimulation. M. AGUILA AND W. S. STILES. *Optica Acta*, **1**, 59–65 (*Jan.*, 1954).

By means of the two-colour threshold method the threshold response of the rod or dark-adapting visual mechanism can be followed to relatively high field intensities. From the results obtained here by this method it is concluded that at a field intensity of about 100 scotopic trolands the sensitivity of the rod mechanism to stimulus differences begins to fall off rapidly and that at about 2000 to 5000 scotopic trolands (corresponding approximately to daylight luminances of 120 to 300 cd/m²) the rod mechanism becomes saturated and is no longer capable of responding to an increase of stimulus. A.

612.843

1930. The eye as transmitter of information. G. TORALDO DI FRANCIA. *Atti Fond. Ronchi*, **8**, 203–11 (*May–June*, 1953) *In Italian.*

The human eye is a transmitter of visual information. It has been customary to think that this transmission takes place in a passive manner. The author shows that on the contrary the eye might play a quite active role. Some evidence derived from the electroretinograms seems to point out that the task of the eye is not only to transmit information but also to reconstruct as far as possible the information that is missing in the input signal on the retina. This reconstruction should be possible to a certain extent because of the non-random character of the visual world. The purpose of a first rearranging of the informational data in the retina would be to facilitate the subsequent stage of interpretation in the brain. A.

612.843.612

1931. Characteristi curves of the human eye. R. W. G. HUNT. *J. Photogr. Sci.*, **1**, 149–58 (*Sept.–Oct.*, 1953).

An attempt has been made to derive these under various states of adaptation. Although they have been derived from luminance discrimination data, it has not been assumed that each discriminable step of luminance corresponds to the same sensation interval, nor has it been assumed that numbers of sensation intervals can be integrated; the curves are therefore free from the criticisms that are often levelled against the Weber–Fechner law. This has been accomplished by analysing luminance discrimination data from a physiological, rather than a psychological, point of view. The curves obtained are consistent both with apparent brightness and contrast data, and with electrophysiological studies, and they permit a simple quantitative explanation of the variation of luminance discrimination with field size. A.

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77.023.4

1932. On photographic chemical development. S. SUGAI AND J. FURUICHI. Note in *J. Phys. Soc. Japan*, **8**, 681–2 (*Oct.*, 1953).

The activation energy was determined by development of photographic emulsions. It increased with the AgI content of the emulsion, from 0·62 eV at 0% to 0·91 eV at 40% AgI, the lower value being the activation energy for ionic conductivity of AgBr. S. T. HENDERSON

771.53 : 538.22

1933. Attempt at an experimental check of the hypothesis of J. W. Mitchell on the formation of the photographic latent image. N. PERAKIS. *Helv. phys. Acta*, **26**, *No.* 3–4, 258–66 (1953) *In French.*

The thermomagnetic study of pure AgBr and Ag_2S is considered to support Mitchell's views on the importance of solid solutions of these salts. In such solutions the diamagnetic ion S^{--} should be replaced in part by the paramagnetic group S^- *F*-centre. This

is equivalent magnetically to Ag^{++} *F*-centre. Measurements on the diamagnetic susceptibility of AgBr and Ag_2S up to >400°c and calculation from these results provides a theoretical curve for the variation of susceptibility of the solid solution with temp., but experiments with the salts in contact or mixed give a different curve. This is due to the formation between 210 and 400°c of the expected paramagnetic component. The amount of Ag^{++} to produce the max. effect observed is 0·008 g ion.

S. T. HENDERSON

771.534 : 539.165

1934. The action of β-rays from Tl^{204} and from Sr^{90} on ordinary photographic films. T.-T. OUANG AND E. MONTEL. *C.R. Acad. Sci.* [*Paris*] **237,** 800–2 (*Oct.* 12, 1953) *In French.*

The measurements of the response of two types of photographic films when passed at a speed of 6·6 cm/s at a distance of 2·5 cm from 5 mc sources of Tl^{204} and Sr^{90} show that it should be possible to measure the emulsion thickness during manufacture by an electron absorption method, without producing any objectionable photographic effects. A. C. COATES

771.534.1 : 541.183.24

1935. The adsorption of hydroxyl ions to silver bromide and its photographic implications. B. P. BOURNE AND E. E. LOENING. *J. photogr. Sci.*, **1,** 159–62 (*Sept.–Oct.*, 1953).

It is analytically shown that hydroxyl ions are adsorbed to a silver-bromide precipitate (silver body), the degree of the adsorption increasing with increasing pH. At the highest pH accessible to the analytical procedure (pH = 9·5) roughly one OH-ion is adsorbed per 5 surface ion-sites. Although OH-ion adsorption to the bromide body could not be readily shown by the analytical procedure its existence is by no means excluded. The possible correlation between the postulated silver-hydroxyl surface complex and photographic sensitivity is briefly discussed and the hypothesis of a dual mechanism of latent image formation is reiterated. A.

772 : 621.383 : 537.533

Photography with "exo"- and photo-electrons. *See Abstr.* 1366

778.3 : 522.615

1936. Influence of temperature on the sensitivity to electrons of some non-colour-sensitized photographic emulsions: application to photographic recording with the electronic telescope. M. DUCHESNE. *Bull. astron.* [*Paris*] **17,** *No.* 2, 107–16 (1953) *In French.*

Tests of 8 different blue-sensitive emulsions at low temperature (−160°c), and pressure around 1 mm Hg within the plate-chamber used for the exposure to electrons, show that the contrast factor [gamma?] of the recorded electron-image is dependent on the accelerating voltage, e.g. for an emulsion giving a factor of 0·2 at 10 kV, the value rose to 1·3 at 25 kV. Of the emulsions tested, Ilford Nuclear G5 was superior in sensitivity to all other types at 10 kV, but could not be used at low temperatures on account of its extreme fragility. On the same account, Ilford Q3 emulsion, which showed superior sensitivity at 25 kV, was not satisfactory. Of the remaining emulsions examined, Kodak Sound Recording 1357, and Positive Graphical Arts 1301 films, and Kodak Q [B?] 10 plates were found sufficiently sensitive for routine use: they showed negligible grain, and freedom from chemical fog. [See also Abstr. 6 (1953).]

D. R. BARBER

778.3 : 532.65 : 531.717.1

A photographic method of observing the approximate size of liquid droplets produced by an atomizer. *See Abstr.* 1082

778.33 : 537.533

1937. Report on the investigation of betatron radiographic techniques. C. J. SMITH. *Non-destr. Test.*, **11,** 17–22 (*Sept.*, 1953).

Using a 22 MeV betatron and U, Fe and Pb objects, it is shown that lead is the best material for both front and back screens and the optimum thickness of front screen to minimize scatter is 0·12 in. A technique of beam flattening is discussed. F. T. FARMER

778.33 : 578

1938. A microphotometer for microradiography. S. BOURGHARDT, S.-O. BRATTGÅRD, H. HYDÉN, B. JIEWERTZ AND S. LARSSON. *J. sci. Instrum.*, **30,** 464–6 (*Dec.*, 1953).

The microphotometer records the transmission in the primary image of an object down to 2–3 μ^2 under visual control. The electrical construction gives a linear amplification in the transmission range actually used. The object is moved across the measuring light beam and, synchronously, the transmission curve is recorded by the writer. The accuracy of the apparatus was found to be better than 1%. When the test included the photographic-photometric procedure in X-ray microradiography the standard error was ±1·5%. A.

778.34

1939. On the shrinkage factor of nuclear emulsions. L. H. GREENBERG AND R. N. H. HASLAM. *Canad. J. Phys.*, **31,** 1115–20 (*Nov.*, 1953).

A simple and accurate method of determination is presented. Its use shows that the shrinkage factor is not a function of the angle of inclination of the alpha-particle tracks in the emulsion. A.

778.34

1940. Transfer on to glass and treatment of unsupported nuclear emulsions. G. KAYAS. *J. Phys. Radium*, **14,** 621–2 (*Nov.*, 1953) *In French.*

Experimental details are given of four methods for achieving good adhesion of emulsion to glass.

J. J. WILKINS

778.34 : 539.165

1941. Autoradiography of the β rays of potassium. A. HÉE AND M. JAROVOY. *Ann. Géophys*, **9,** 153–7 (*April–June*, 1953) *In French.*

Ilford plates were used, and the effects of cosmic rays were eliminated using the method of G. Albouy [Abstr. 6930 (1950)]. Results are given as histograms. The difficulties are discussed. F. R. HOLT

778.34 : 537.591

The production of delta-rays in nuclear-research emulsions. *See Abstr.* 1451